FISH PONDS

FOR THE FARM

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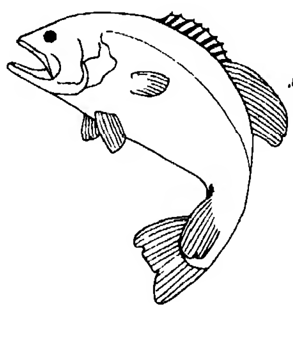
By

FRANK C. EDMINSTER



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TO MY WIFE

PREFACE

This book is written for people who live on the land and enjoy the sport of fishing, and for those who would like to do so. It will have succeeded in its purpose if it helps its readers to obtain a fuller enjoyment of outdoor life and a keener sense of companionship with the wild life of the pond.

I want to thank Mr. W. L. McAtee of the United States Fish and Wildlife Service for his expert, critical editing of the manuscript; Mr. Homer S. Swingle of the Alabama Agricultural Experiment Station for adroit technical advice; Mr. Douglas E. Wade of Dartmouth College for helpful suggestions with the text; the United States Soil Conservation Service for permission to use all of the photographs; and Mr. Herbert J. Raths of the United States Soil Conservation Service for assistance with the chapters on design and construction of ponds.

F. C. E.
Upper Darby, Pa.
August 15, 1947

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FISH PONDS YESTERDAY AND TODAY

FISH have a fascination for folks possessed by few other animals and the great sport of fishing has developed as a result of this attraction. The many fine foods we get from the esculent fish is surely one of the reasons men have been spurred to grow them under controlled conditions and make of fish a crop of the land and water.

ANTIQUITY OF AQUICULTURE

The story of man's efforts to produce a crop of fish in ponds antedates recorded history. The exact epoch when the Chinese began this culture is not known but all evidence points to its being in the farthest reaches of antiquity. It is likely that other Oriental peoples, the Filipinos, Japs, Indians, and others, also grew fish in ponds at a very early time, although the evidence is less clear.

Various early missionaries have written of the methods employed by the Chinese.[1] Rural people gathered fish spawn from the rivers each May. Some were taken from holes in the bottom by divers who learned to recognize the eggs by the "eyes." Mostly the river was barred with nets, mats, grating or hedges of branches which sieved out the eggs as they floated downstream. These people became very proficient at this business, whereas the ordinary person would be unable to see the spawn at all.

[1] See *History of the Chinese Empire*, vol. i, p. 35, 1735, by John Baptiste Duhalde; also, *La Pisciculture et all Pêche en Chine*, by P. Dabry de Thiersant, pub. in Paris, 1872.

The fish spawn was placed in vessels with water and sold to merchants who came by boats to the place for this purpose. They in turn transported the ova elsewhere, taking care en route to keep the water in the containers agitated so that the eggs would receive aeration. The spawn was placed in the ponds of the boatmen or sold to other owners of ponds. Thus they made the stocking for a crop of fish.

A variety of fish were stocked, somewhat indiscriminately, in this way since the spawn could not be identified as to species. Among the kinds prominently mentioned were carp, tench, salmon, trout, and sturgeon. In most instances the eggs were placed directly in the pond, now empty of fish, the last crop having been harvested. By this time the fish embryos had developed almost to the point of hatching.

A curious technique was added to this procedure in some areas.[2] Hens' eggs were emptied of their natural contents, which were then replaced with the gelatinous fish spawn and re-sealed. These eggs were then incubated by fowls for a few days, taken away and emptied into vessels of water heated by the sun. The embryos were allowed to develop fully and hatch in these containers. Here they remained until the young fish developed enough strength to bear transfer to the ponds without great losses.

The young fish fry were then fed with lentils gathered from marshlands, and with the yolks of eggs. The fact that such valuable human foods were used as feed for the fish is evidence of the great value placed upon them. In more recent times, but yet a long time ago, the practice of feeding the fish was largely displaced with methods of inducing natural foods in the pond through increasing the fertility of the water. This was done largely through the use of "night soil" (the contents of privies, generally gathered at night) as fertilizer.

Through these means a crop of fish grew in the pond for one, two, or three years. Then the pond was drained, or netted, and the entire crop of fish taken. The following May, the whole process was repeated.

The Romans followed somewhat similar practices at a very early time. Writings of the first century A.D.[3] describe the spirited competition among the

[2] See *Historical and Descriptive Account of China*, vol. 2d and 3d, p. 435, Messrs. Murray, Crawford, Gordon, Lynn, Wallace and Burnett, Edinburgh, 1836.

[3] See *Columella, DeReRustica*, book VIII, section 16 (translated into English in eighteenth century).

landed gentry to have a great abundance of all manner of food grown on their places. Fish were among the most highly prized of home-grown epicurean delicacies. People built ponds for the purpose, and stocked natural lakes and ponds too.

Often the prima (or first) course of the bacchanalian feasts of the Roman patricians was fish of one or more varieties. During the centuries immediately before and after the birth of Christ this vogue became a passion. The rich indulged unreasonable expense in fish preserves, splurging in scandalous luxury.

The system used by the Romans was essentially the gathering of all manner of fishes into ponds, letting them prey upon one another, and utilizing the survivors. They gave the fish various feeds too, and it is said that they even used the flesh of slaves for this purpose.[4] This was purported to impart a particularly delicate flavor to the fish. But despite the great attention paid to aquiculture, it must be said that the Romans did not advance the art appreciably. They were more interested in food than in science.

SPREAD OF POND-CULTURE THROUGHOUT EUROPE

The arts attending the fish pond spread throughout Europe during the Middle Ages and many advances were made in methods. As with most other cultural achievements of that time, this work was largely carried on — or at least recorded — by religious groups Most royal personages had their own fish preserves in artificial ponds. The great Charlemagne in the eighth century, for example, is depicted as paying attention to keeping his ponds in good repair.

Throughout most of this period the advance in techniques was largely in details of handling the spawn, feeding the fish, arranging the ponds, and the like. No great new principles were discovered. Then toward the end of the Middle Ages, in 1420, a monk named Dom Pinchon is supposed to have conceived the means of artificially fecundating trout eggs by pressing out the spawn and milt, in turn, from ripe female and male fish. Mixed together in the water, the eggs were thus fertilized under man's control. Thus began the science of pisciculture, or breeding of fish, as contrasted with aquiculture, the culture of pond life.

[4] See Report of U. S. Fisheries Commissioner, 1872–73, p. xxxi, pub. in 1874.

I say that Dom Pinchon is *supposed* to have made this discovery. He is so credited by Haime,[5] but other authors give recognition to J. L. Jacobi, a German. His revelation of artificial fecundation in 1763 was properly recorded in the literature of the time.

It will not suit our purpose to pursue the development of artificial fecundation of fishes since this technique was and is used in fish hatchery work, not in pond culture, except to provide fish for pond stocking. Suffice it to say that great refinements in the handling of breeding fish, their sexual products, and the resulting young developed through the nineteenth century. These may be seen in operation today in any of our modern fish-producing stations throughout Europe and America.

Pond culture spread to England in the early part of the sixteenth century with the introduction of carp in 1514 and pike in 1537. A considerable literature on the subject developed from about the start of the eighteenth century. From these writings we may see how great was the advance in pond culture through the preceding centuries.[6]

Specifications for construction of ponds best suited for growing fish were given in terms that are almost as good today as then, as: the use of the clay core in earth-fill dams, proper sloping of the sides of the dam, adequate width of the top of the fill, provision of freeboard above the normal water level, and building of diversions around the ends of the embankment to dispose of flood waters.

These features were advocated in 1713, but recognition of the importance of a controlled water supply to keep the pond full but not flooded was not mentioned then. Over a century later Boccius brought this point out, noting: "It is not desirable to have the ponds so situated that a large quantity of fresh water shall suddenly be able to find its way into them . . ."

North recognized the problem of maintaining a balance of fish in the pond. He said: "I have found a great analogy between the stocking waters with fish, and pastures with cattle. . . . Waters may be overstocked, as pastures often are; so both may be understocked. The latter is the less error; for if you overstock, you

[5] See *The History of Fish-Culture in Europe from Its Earlier Records to 1854*, by Jules Haime; first pub. in *Revue des Deux Mondes*, Paris, June 15, 1854 and translated for Report of U. S. Fisheries Comm., 1872–73.

[6] See *A Discourse of Fish and Fish Ponds*, by Roger North, London, 1713; *A Treatise on the Management of Fresh-Water Fish*, by Gottlieb Boccius, London, 1841.

lose the whole summer's feed; if you understock, you lose only the rest of your profit. . . ." What better explanation could be asked of our concept of balancing the numbers of fish to the food supply? He then goes on to suggest the correct numbers of fish to stock, and by inference warns against overstocking, an error in which many modern fish conservationists still indulge. Carp was the main species used, but North knew the need for other kinds and saw the value of a carnivorous variety to help maintain the pond balance naturally: " . . . 300 carps per acre . . . forty or fifty tenches for a trial. . . . You may add perches. . . . I propose 600 . . . they devour their own species as much, if not more than any other; and by destroying the fry of breed fish, they preserve the food for the maintenance of the feeders. . . ." He warns against pike: " . . . they are dangerous guests . . . ", although " . . . inferior to no fresh-water fish, . . . they will devour and destroy the best fish. . . ." It remained for Boccius to state forthrightly the need for an effective predator fish. "Jack or pike is well known to be the most rapacious fresh-water fish that exists, but with all its voracity it is absolutely necessary to have a sufficient quantity in the carp . . . ponds, to check increase . . . " is the firm way he stated the case.

In the late seventeenth–early eighteenth century period of which North wrote, two and one-third centuries ago, the need for a thorough harvest of the annual fish crop was realized. He said that " . . . unless you have projected before-hand how you shall dispose of your fish, you will find yourself in great disorder." The use of fertilizers and feeds had broadened considerably beyond the Chinese customs, but only as to materials used. All of them were organic, those frequently mentioned including sheep manure, malt, grains, carrion, and slaughter-house refuse.

Caution was raised against ". . . dunghills, stables, or cowhouses, permitted to drain into ponds for they are very ill neighbors. . . ." He was apparently concerned over the possibility of an oxygen deficiency arising, which we recognize today where organic contamination is high.

Woody plants in or close to the pond were considered bad " . . . not only from its hindering of the wind and sun from purifying the water, but from the leaves falling in, and rotten wood; both of which are pernicious to fish." Boccius was more specific later on as concerns plantings around the pond: " . . . it must be fully borne in mind that trees and shrubs should never be planted in the borders

. . . of ponds, but if ornament be required, then only at a sufficient distance. . . ."

It was thought in those days that a series of ponds was the ideal arrangement, usually with each one draining into another below it, there being at least three of these. One, which was the primary producing pond, would be a couple of acres in size or bigger, and another, known as a "stew," was small and reserved for holding fish ready to take to the kitchen. North felt that "one great point in the conduct of fish, is, to have them at command; another is to have perpetual recruits. . . ." Thus, the "stews" provided the fish "at command" while the other ponds produced the "perpetual recruits." The yield from such a system of ponds of " . . . four acres . . . shall return you every year 1,000 carp fed up, from — to 14 or 15 inches, besides pike, perch, and tench . . ."

As to the merit of the "stew," which we would now call a holding pool, it is the same today as then. A friend of mine in New Jersey has a small spring-fed holding pool, just a few feet in diameter, where the fish are placed after being caught in his pond. When a mess of fish is needed for the table, he then dips them out with a hand net.

The basis of the older system of fish raising was the carp. North thought there was little difference in the so-called strains, or in their taste. Here there is great difference of opinion among authors. Boccius wrote of two species, the " . . . English or round-bodied carp. . . . the Spiegel (Mirror) carp . . . obtained from . . . Germany. . . . The Spiegel carp is the better flavoured. . . ." The debate continues today, but this may be said. The carp later brought to the United States generally proved ill-flavoured. Contrarily, in central Europe today, or at least prior to the recent war, there were ponds of pedigreed carp that satisfied the exacting tastes of wealthy gourmets.

The recommendations of fish-pond authorities a century ago, among whom Boccius is cited as typical, were not greatly different from those of the previous century. Some refinements were developed, as noted, but there were others, too, worthy of mention.

The relationship of soils to water productivity is pointed out by Boccius. He said "Clay soils are not genial to fish. . . . In clay bottoms the fish do not thrive, from want of food, in consequence of the water partaking of the . . . quality of the earth, which from its cold and sterile nature does not afford the nutriment requisite for the maintenance of the larvae of insects, worms . . . in

sufficient number. . . ." He recognized the principle of carrying capacity: "It has been fully proved that a given space of earth can produce only a certain quantity; so only can a given space . . . of water produce a certain quantity, either of vegetable matter or animalcules . . ." The wisdom of accurate stocking of the pond was emphasized: " . . . by storing only the proper number of fish adapted to the water, the weight in three years will prove equal to what it would have been had twice the number been placed therein. . . . By overstocking the water, the fish become sickly, lean and bony. . . ."

Boccius placed great accent on the predator fish, the pike, to check the increase of carp. "Carp . . . being so productive, require a . . . check by a . . . quantity of jack in the stews (he called *all* ponds "stews"), otherwise the water would soon become so swarming with brood, that food would be wanting to support the stock. . . . Jack became a useful appendage in well-regulated ponds, tantamount to an absolute necessity. . . as it will be found that jack, carp and tench thrive and grow in equal proportion after this system. . . ." His recommendation for proper stocking of an acre pond was 200 carp, 20 tench, and 20 jack, all "brood" fish. How like our present day 10 to 1 ratio for stocking forage and predator fish!

The techniques of handling fish ponds here noted were used, with minor variations, over most of Europe, and especially in England, France, Germany, Italy, Finland, Hungary, and Russia. During the last part of the nineteenth century, those interested in fish problems concerned themselves more with the development of fish breeding than with pond management. Few changes were made in the customs of the previous century, and thus the ponds of Europe are cared for today much as they were a hundred years ago.

One development deserves special note, as an exception. The Rhine valley in France saw the development of a type of combined aquiculture and agriculture, unique in the whole world. Large fields were flooded with shallow water following a year or two of grain crops. These were then stocked with carp, which benefited greatly from the good food supplies induced by the fertile soil conditions. When the carp crop matured, the fish were harvested and the field drained. Then it was sowed to grain again, and the cycle continued. Apparently this is the outstanding instance of a crop rotation including fish along with dry land products.

EARLY INTEREST IN PONDS IN THE UNITED STATES

"They began to work again on the fish pond made by the dam at the junction of Valentine and Reed's branches; it is to be deepened three feet, the water to be diverted into the race." This quotation is from the diary of Charles Carroll of Carollton, signer of the Declaration of Independence, the entry having been made on August 27, 1792. This diary constituted a journal on the management of his estate at Doughreghan Manor, Howard County, Maryland, and is now in the Maryland Historical Society library at Baltimore.

What Squire Carroll did with his fish pond after it was finished we are not sure. The instance does show, however, the early interest in fish ponds in this country, no doubt carried across the sea from England. However, America being a virgin land, there was such an adequate supply of good fish in all the natural streams, ponds, and lakes, that the need for artificial fish ponds was not felt. There being no pressing reason for their development, little was done until late in the nineteenth century.

One rather significant occurrence of the 1850's was the transplantation of black basses, probably of more than one species, from its native waters to new areas where it had not previously lived. This interest began in New England and spread to other states from there. Milner[7] recounted that in 1854 black bass were carried " . . . in the water tank of a locomotive from the Ohio River . . . to . . . the Potomac . . . in time the entire river became thoroughly stocked . . . bass found immense numbers of . . . chubs, minnows, suckers, etc. . . . (and) extended their limits toward the mouth of the Potomac. . . ." After some years (less than twenty, since this was written in 1872 or 1873), " . . . however, . . . on the upper Potomac, . . . bass are becoming scarce. . . . This is a very natural consequence. . . . In the increasing scarcity of herbivorous fish, the bass will be driven to feed more and more upon each other, and after a time a certain average will be established, perhaps the same as that existing in the . . . Mississippi . . . where, although indigenous, they are in proportion fewer than in the Potomac."

While this was not pond culture, it does bring to attention one of the species that was destined to play a vital part in fish ponds about a century later.

[7] *Progress of Fish Culture in the United States*, by James W. Milner, in Report of U. S. Fisheries Commissioner, 1872–73, pub. in 1874.

It was inevitable that the European system of carp culture would be brought over here sooner or later. As the fishing in streams and ponds waned, carp ponds were advocated for farmers and a wave of interest swept over the country. But the enthusiasm for growing carp soon declined as it was found that these fish did not suit the American palate. Whether this was the result of introducing an inferior variety of carp, or due to a more discriminating taste in fish flesh is still somewhat a question. At any rate, the ponds were left uncared for, and the carp escaped into many of our rivers and lakes. Here we have cursed them ever since for their bad effects on aquatic vegetation and native fish.

THE MODERN FISH POND, AMERICAN STYLE

It is rather strange that efforts were not made earlier to discover the possibilities of producing our many fine, native, warm-water fish in ponds. No doubt this delay was due in part to the discouragement wrought by the unfortunate experience with carp. In part, too, it was due to the relative lack of urgency. We still had fairly good fishing in natural waters, available to all who wanted it. Contrast this with conditions in Europe where no public fishing remained for the common people.

Anyway, it was well along in the present century before the lull was broken. Just prior to the first world war a new interest in ponds began to grow. I think that the man who was as responsible as any for that program was Prof. George C. Embody of Cornell University, the late, eminent fish culturist. It was in 1915 that he published his bulletin "The Farm Fishpond" in the "Cornell Reading Courses" series. And I may say, too, that my own interest in fish and other wildlife received a great impetus at that time for, although still a youngster, I first became a pupil of Embody's that summer.

Embody's bulletin summarized the most advanced thinking about fish ponds at that time and revealed many points of progress over earlier customs. Probably most significant was his reliance on native fish for the primary species of the pond. Those he urged were the black basses, sunfishes, perch, rock bass, bull heads, calico bass and the like. These he termed the "edible fishes." To go with one or more of these kinds he advocated the use of a "forage fish," that is, one whose food is largely vegetable. For this, goldfish and golden shiner were suggested.

The need for developing a large and continuous food supply for the fish was recognized, and to do this a rather complicated series of arrangements were set up. The construction plan called for " . . . the greater part of the pond less than three feet deep, for in the shallows fishes find their sustenance." He did recognize the danger of ice, though, and said " . . . there should be an area at least six feet deep where the fishes may gather during the cold season."

Surrounding the main pond there were to be a series of little ponds each fifteen to twenty feet across, connected to the main pond by a narrow channel across which a fine screen was placed. In these side pools well-rotted manure was placed at " . . . the rate of about three quarts per square yard. . . ." Here developed the small organisms that would, in rotation among the little pools, be opened to access of the fish. He also advocated placing leaves, waste hay, ". . . or even . . . a small amount of horse manure" in the main pond to improve its fertility.

Great emphasis was placed upon correct procedure in stocking the pond. First came the provision of aquatic plants. This was done in the spring. These furnished food for the forage fishes, aided in developing small animal life, provided spawning places, and purified the water. Species such as the pondweeds (*Potamogeton*), wild celery, water-milfoil (*Myriophyllum*), hornwort (*Ceratophyllum*), elodea, water cress, duckweeds, water lilies, and even the filamentous algae were considered desirable. This effort to develop fish food from leafy aquatic plants, even though related to the use of herbivorous fish, would seem to be a retrogression, as many older writings had argued against it.

Next step in stocking the pond was to collect quantities of forage animals: fresh-water shrimps, water sow bugs, snails, and small clams, and place them in the main pond. This procedure followed establishment of the aquatic plants by a month or more, about June. Soon afterward, the forage fishes were placed in the pond — about a hundred pairs each of goldfish and shiners.

Lastly, the edible fish species were added, but not until the food conditions were good. Fingerling black bass might be stocked in the succeeding fall, using about two or three thousand per acre. If other edible species than black bass were used, twice as many were needed.

Among the most interesting aspects of this whole system was the stocking rates of the two types of fish. They are substantially the reverse of what we now

believe to be correct. Of course the few forage fish suggested were expected to produce young before the several thousand bass or other edible fish were added. The desire for a high proportion of useful fish, that is fish to catch and eat, may have led to some wishful thinking.

As a matter of fact, the Embody method, while advancing both interest in fish ponds and in the science of aquiculture, did not receive wide use. In all likelihood, this arose from the rather complicated arrangements and techniques. The high share of non-edible and unfishable fish in proportion to the others no doubt added to the discouragement of those who tried it.

The next significant step in fish pond science brings us to the early 1930's and to Alabama. A certain fishing club that owned a property including a lake, saw the fishing in that lake go from bad to worse, and from worse to — well, to almost nothing. Among the club members were two agricultural scientists from Alabama Polytechnic Institute, H. S. Swingle, an entomologist, and E. V. Smith, a botanist. They reasoned that the lack of balance among the fish species resulted in an overpopulation of some kinds, that the weeds which nearly choked the pond were a contributing impediment, and that the water was not fertile enough to produce many pounds of fish anyway. The club membership was polled on the idea of letting Swingle and Smith try their hand at improving the fishing. Having nothing to lose, they acceded.

Such was the humble beginning of the largest fish-pond experimental project in America. For the result of their first test was so successful, and so stimulating, that the State Agricultural Experiment Station undertook to start a research project on fish-pond management. Today the station has some thirteen hundred acres of land devoted mainly to this work, with 116 test ponds built and more planned. From this work have come most of the refinements in handling ponds we use today.

Among the notable advances made was the use of N-P-K (nitrogen-phosphorus-potassium) fertilizer in the pond. Embody had mentioned that German scientists were experimenting with inorganic fertilizers, but apparently he did not use them himself. Swingle and Smith demonstrated that these complete chemical fertilizers are superior to the organic types for fish pond use. Their composition is precise, and their effects predictable. Simplicity in handling, ready availability, and low cost added to their practicability.

Swingle and Smith reaffirmed the need for weed control and for a balance of predaceous and forage fish species. But the fish they found to be suitable were a simple combination of one carnivore — the large-mouth bass, and one pan fish — the bluegill sunfish, or bream. Through simplicity of the fish combination, they attained simplicity of management — and certainty of results.

The choice of these two species proved wise because of a number of their characteristics. The bass is an effective predator, and is well able to keep the bream from becoming too numerous. Yet it is not so voracious as to prevent its being kept in balance itself, even in small ponds. It reproduces well, grows rapidly, and provides good sport and good food. The bream is not only an effective forage fish to feed the bass, but is itself a good food fish and furnishes fair sport too. This is in notable contrast to goldfish and shiners formerly used that served only to feed the bass. The bream is likewise a fast growing fish and reproduces prolificly in ponds without specially prepared spawning beds.

The need for control of the water, without it flooding or flowing excessively out of the pond, was given needed emphasis, as well as the necessity of proper design and construction of the pond itself. Management was based on harvest by fishing rather than periodic cropping by draining the water out. This made sport and food production of equal importance. Continuous production by thorough annual harvest and natural reproduction for the next year's crop gave a continuity largely lacking in the Old World systems.

It is fortunate too that Swingle and Smith were not the retiring type of scientist who cares little for public relations On the contrary, as they got results from their experiments they were described in Experiment Station bulletins or presented at scientific meetings. This helped not only to renew public interest in fish ponds but it also stimulated that of other fisheries agencies and their scientists. Men in the United States Fish and Wildlife Service, other state Agricultural Experiment Stations, and state fisheries agencies have contributed to the growing body of technical information on the subject.

HOW NEW IS OUR SYSTEM OF HANDLING PONDS?

Recapitulating, we find that the methods of building, stocking, fertilizing, fishing, and maintaining a small fish pond as we now think it should be done are

based on principles and techniques hundreds and even thousands of years old. Mostly it is the refinements that are new.

The principle of fertilizing the water was practiced by the Chinese something more than 2,000 years ago. Only the *type* of fertilizer and the details of using it are new. The stocking of ponds with fish eggs or young fish and provisions for feeding them are likewise brought down to us from Oriental antiquity.

About two and one-half centuries ago, Europeans recognized the need for reproduction within the pond, for proper construction of the dam, and control of the water. The importance of preventing over-population, the effect of water fertility on fish growth, stocking in proportion to the size of the pond, and taking an annual crop, were all set forth clearly then.

Most of the other basic principles were appreciated more than a century ago. The system of maintaining a balanced population with predator and forage fish species, the control of weeds, and the concept of carrying capacity were all well recognized.

What then is new? Primarily the following tested refinements of principle or method: Use of chemical fertilizers; elimination of artificial feeding; the largemouth bass — bluegill sunfish combination; more complete water control and methods of accomplishing it; new methods of weed control; techniques of checking reproduction and correcting unbalances; more emphasis on sport, rather than food. That is about it. Biologically it does not seem like such an astounding advance. But from the point of view of practical application, it is as the difference between darkness and light.

SPREAD OF POND BUILDING THROUGH CONSERVATION PROGRAMS

The United States has become conservation minded in recent years. Realization of the urgency of preserving our natural resources resulted in advancing a number of land-use programs. The need for and value of water in producing crops of plants and animals was recognized as of primary importance. And pond building is one of the best ways of providing water to farms and ranches. It was natural, therefore, that pond building inevitably became an important phase of conservation work.

Outstanding among the conservation programs has been that of the United States Soil Conservation Service. Dedicated to the principles of good land use — "each acre to its best use, and the best use for every acre" — and the control of soil erosion, it has encouraged the development of ponds on America's farms. Particularly in the drouth-ridden prairie states back in the dry period of the '30's, the building of ponds was a matter of first importance. As the many uses of ponds became more appreciated, interest in them spread throughout the country so that today ponds are being built from Maine to California as a part of the local programs of soil conservation districts. The skilled advice of the Soil Conservation Service technicians is available to farmers who are cooperators of soil conservation districts.

At this point it is probably well to define the "soil conservation district"; what it is, how it arose, and what it does. Every soil conservation district, and there are about 1750 of them today (1947), is a legal subdivision of the state in which it lies. It is organized under a state law enacted for that specific purpose. All forty-eight states have soil conservation district laws on their statutes but progress of actual organization of the districts varies among the states. Their objectives are mainly to promote the conservation of our basic agricultural resources, to enable farmers to organize for effective conservation work, and to bring together all available agency-help that can assist the farmers in getting the job done.

The state laws vary as to the means of organization, but there are two basic patterns: the districts are organized by petition and public referendum; or by vote of the county governing body. Upon completing legal organization, the district governing body, generally called "supervisors," are either elected or appointed. They then undertake to develop a program for the district and to seek means of making it available to farmers and of carrying it out. Almost invariably the building and management of farm ponds is an item in the district program, so great is the interest in ponds.

SOURCES OF AID IN BUILDING AND STOCKING PONDS

As has been indicated in the preceding paragraphs, any person operating farmland within an organized, soil-conservation district is eligible for aid on

problems of soil and water conservation. If you are not sure whether there is a conservation district in your locality, inquire of the county governing body, your county Agricultural Agent, or the local office of the Soil Conservation Service. Where your land does lie in such a district, you may apply to the Chairman of the district's board of supervisors for aid in soil and water conservation work, including ponds.

The majority of soil conservation districts have working arrangements with the U. S. Department of Agriculture whereby technicians of the Soil Conservation Service are loaned for the purpose of developing farm conservation plans. These men are skilled in the techniques of designing and building ponds and in managing them for fish and other uses. In cases of unusual difficulty, they can arrange for help from engineering and biology specialists. Their assistance is limited to technical advice, however. Actual costs of construction must be borne by the farmer. The district may have pond-building equipment available for rent, sometimes with operators, at a reasonable rate, or it may have other arrangements to facilitate building. Conditions vary with the districts.

A source of financial aid for pond work is available in some states through the agricultural subsidies of the U. S. Production and Marketing Administration, Field Service Branch, formerly the Agricultural Adjustment Administration. The various soil-building and other practices for which these cash subsidies are paid depend upon a program developed by each state committee of that organization. Generally your County Agent can tell you about this matter, but most of the programs that support pond-building are in the Mid-West and plains areas.

One of the essentials for a newly built fish pond is the fish to stock it. Cooperators of soil conservation districts who have *bona fide* farm ponds (size must be from one-quarter acre to five acres) can receive fish grown in hatcheries of the U. S. Fish and Wildlife Service. There is no charge for this contribution, nor are there any "strings" attached to the use of the fish after stocking. In some places, mostly in the south, the state fisheries agency also supplies fish for stocking private ponds.

Advice on building or managing fish ponds may often be provided by experts from the state agricultural experiment station, the Extension Service, or from the state fish and game conservation agency. Whether such aid is available in your state can be found out by writing to the agency directly.

MULTIPLE VALUES OF PONDS

Before going on to the details of pond-building and management for fish, let us take just a moment to reflect upon the uses of ponds. Every farm can profit from having a pond, not just in one way, as growing fish, but in many. It has so many practical farm values, as: A dependable source of clean water for domestic animals; water that can be piped to barns for various purposes; or to irrigate the gardens or other special crops; and a ready supply of water for spraying orchards. Then too, ponds close to the home buildings are an aid in fighting fire. Many a barn and farm home has been saved where there was a pond from which to draw water in hose lines.

Cutting ice is a bit old-fashioned in these days of electrical refrigeration but still there are many places where the old ice house is still a sound asset. A convenient pond is a ready source of ice.

These are the utilitarian views; they are the immediate reasons why folks build ponds — or at least, why they say they do. It looks better that way in the farm account books. While I do not for a moment discount the importance of these services, I firmly believe that these are not, in general, the best fruits of the pond. Certain intangibles beyond the measurement of money are the reasons why ponds are popular; they are why more and more people want to build them.

In a thimble, it is the measure of better living that the pond contributes, the satisfaction of enjoying its beauty and its life. A pond is a fascinating scene through the seasons. It seems almost to create its own sense of being alive. The spring peepers that appear out of nowhere to fill the first days of the new season with lusty song; the dragonflies that hover, like helicopters not needing a rotor blade, over the water to catch any mosquito that has escaped the fish; the tree swallows nesting in the birdhouse on the pole, which swoop so gracefully through the warm summer air; the eery, gray mists that rise from the pond surface in the dawn of a cool autumn morn; the sealing blanket of ice and snow that comes with winter, preserving the virtues of the pond for another year; these, and countless other vignettes of the pond, are amenities that make the pond invaluable.

Between the "practical values" and the real intangibles lie the "applied" recreational uses of the pond: swimming in the summer; skating in the winter; picnicking throughout the year; a little duck hunting in the fall and muskrat trapping in early spring; and, of course, the subject of our little book — fishing!

2

LOCATION OF THE POND

GREAT care should be taken to find the best possible place for building a pond. Both economy of construction and success in producing fish depend on choosing a suitable site. There are a number of things to be considered, three of which are vital. These are: soil type, water supply, and topography. The latter includes the dimensions of the pond. Other matters may sometimes affect the choice of location, but first let us go over these just mentioned.

SOIL TYPE

The *soil* must hold water. This means that the topsoil or subsoil must have enough clay in it so that it is water-tight — *impervious* as the soils scientist says. The material from which the dam is to be built must also make a perfect seal, at least in the center section — the core. Such soils are ordinarily quite heavy: clays, silty clay, clay loams. They may lie in a well-drained spot or in a poorly-drained one, but they are never drouthy. The sites to be avoided are sandy and gravelly soils, or where limestone or shale comes close to the surface.

If you are in doubt as to the sort of soil you have, it can be tested by the County Agricultural Agent. He will be able to tell you about its water-holding character. Several samples should be taken representing all parts of the proposed site. Each location should have two samples: one from the top layer, three to ten inches deep; the second from the subsoil, ordinarily ten to twenty-four inches below the surface.

Even if these tests show the area to be suitable, it will be wise to make still further tests before you decide to build on it. The pond area will usually require some excavation to furnish fill for the dam. This might expose a seepy layer. Test holes dug just above the proposed dam site and filled with water will reveal any such strata if the water drains down quickly.

The search for a place with suitable soil for holding water may prove vain. However, it is still possible to build a pond, if other requirements are met, but it means extra expense. Bringing in clay or commercial soil-sealing products to cover the bad spots can correct the fault. We shall discuss this a little later.

WATER SUPPLY

The source of water that is to fill the pond and keep it full must be given the most careful attention. First, there must be enough water flowing in to avoid drying up during drouthy spells. Ideally, the pond should be kept full at all times. Equally important is the need for avoiding an excess of water. From the fish management point of view, all water that flows out of a pond is waste — excess. This must be kept to a minimum, even including the quick surface run-off after heavy rains. Thus the ideal water supply is one that keeps the pond full without any running out.

Most fishermen do not understand this need for limiting the water moving through a pond. The usual impression has been that the more water, the better it was for the fish. It is easy to see why this is wrong when one considers that we are going to make the pond a *fertile* medium for raising fish. The pond gets that way by the addition of fertilizer to the water that flows in. Thus it is readily seen that the more of this fertile water that leaves the pond, the harder it will be to keep it productive. If the outflow is too rapid it becomes impossible to maintain or raise the fertility.

There are three usual sources of water for the pond: springs; streams; and surface run-off from rainfall. Any one is satisfactory *provided it is under control* and is not contaminated.

Ponds built at or just below spring heads are among the best. Most springs have enough flow to keep a small pond well supplied but not so much as to cause trouble. Then, too, a spring is a steady and dependable source. It does not flood

during high rains or dry up in a drouth — that is, if it is a good spring. Hence one should look over any spring locations as the first possible sites for a pond.

Streams *may* be a suitable source for our pond water. However, we should quickly discard any notion of building the pond across the stream valley. Any stream worthy of the name will flow too much water through the pond for good fish conditions. Thus, when we look over stream valleys for pond sites we must seek a situation where the stream can be made to flow *around* the side of the pond without going through it. The water for the pond can then be brought from the stream in a pipe or small ditch.

Selection of a good pond site close to a stream requires careful planning. Not only must the normal stream run by-pass our pond, but its flood flow at times of high water must also be kept out. This often requires the building of an extra high embankment between stream and pond, or a new channel for the relocated stream. It does enable you to have perfect control of the water entering the pond, which is a good advantage. This assumes, of course, that the stream does not dry up in rainless periods. Intermittent brooks are not very satisfactory.

Good ponds can be built without benefit of any active source of water, spring, or stream. These are often called *sky* ponds because they receive their water from the sky as rainfall. Whether any particular site can be employed for a pond that uses only surface water depends upon the watershed that lies above. Here again, as with streams, we want a *moderate* water supply. The watershed should be big enough to keep the pond full most of the time; but not so big that the pond will be flooded in heavy rains.

In the humid areas of the east and south, a watershed of ten to twenty acres of open fields for every acre of water surface in the pond is generally about right. If the soils are generally poorly drained, the lower figure is better. If the soils are well-drained, nearer twenty acres for each surface acre of water is better. In all cases, the fields must not erode. Else our pond will fill with silt and be ruined. When the watershed is in woodland, more acres are needed to supply water. Because woodland absorbs and holds more water than open fields, it takes about twice as much, say twenty to forty acres of woods for each acre of pond. Of course, if the watershed is partly wooded and part in fields, we use their acreages proportionately to figure our needs. Sky ponds are not practicable in arid regions

When you have measured the watershed above a possible pond site and found it either too big, or too small, it may be possible to correct the situation — by using diversion terraces. With one of these shallow ditches, excess watershed may often be cut off and the water disposed of elsewhere. Similarly, if we want *more* water, a diversion terrace will sometimes enable us to increase the effective watershed. In such cases, it is well to call in a soil conservation expert.

TOPOGRAPHY

Topography is the surface features of the area. The lay of the land should provide a place where a good-sized pond can be made with a small dam. A pond *can* be built almost any place. A flat plain can be excavated to make a pond — if one is willing to move out a cubic yard of dirt for every yard of water volume. A mountainside draw can be dammed to make a pond if the cost of the job is not important. However, if you are like most folks, the cost must be moderate.

The ideal topography is a saucer-shaped area with the rim broken by only a narrow gap, like the spout of a pitcher. This gap is where the dam goes to complete the saucer. It provides a big volume of water held for a small amount of earth moved. The more a site varies from this ideal, the less we get for our expenditure. The practicability of building a pond depends upon whether the cost of the structure is repaid by the pond that results.

The place to look for is one with a flat area surrounded on three sides by short, steep slopes. The fourth side, where the area drains out, should be as narrow as possible. The side slopes should constrict to shorten this gap — the construction area, or axis of the dam.

When you have picked a likely place, you should then find out just how good it is by making a topographic survey. This may sound difficult but it is really very simple. The tools needed are some sort of level, a measuring rod, and a measuring tape. The most accurate job can be done with a good surveyor's level, or a transit. For most purposes an Abney level, any small sighting level, or even a string level will be good enough. The rod, about twelve feet long, should be marked in feet and inches (or in tenths of a foot) to sight on The tape can be any convenient means of measuring distances on the ground.

You begin by starting at the low point of the area, at or just a little below

where you think the dam should go. Place the rod here and sight on it from a position within the pond area and well above the base of the rod. Then move the rod ten feet to one side on a line at right angle to the slope. Make another reading. Repeat this until the rod position is well up the side slope and at or above the likely pond level. Do the same series of measurements on the other side, going up the other side slope. This gives us the figures to depict one cross-section line. These figures may look something like this: 11.5; 11.4; 10.9; 9.7; 6.9; 2.1 for one side. Then, beginning at the center again: 11.5; 11.1; 10.7; 10.2; 7.5; 3.4; 2.1 for the other side. (Here the figures are given in feet and tenths of a foot.) Always complete the line at the same level; here it was 2.1. This is the point that looks like the best water level for the pond.

These figures may then be plotted on a piece of paper to show the section graphically. Cross-section paper is easiest. They would look like this:

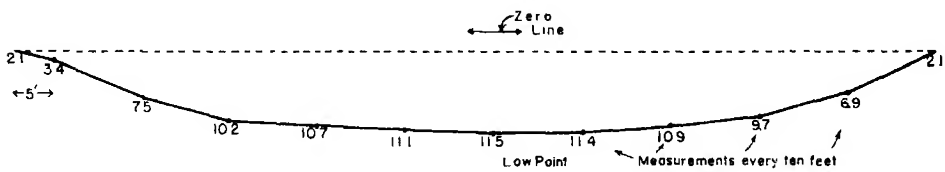


FIGURE 1. Graphical section across likely dam site. Figures represent feet below eye-piece of sighting instrument which is used as the zero line

Now go back to the low point again with the rod. This time move it ten feet *up* the slope, into the pond area. Repeat the same series of notes at ten foot intervals on each side until 2.1 is reached. The last space will usually be some fraction of ten feet.

This same process is followed at ten foot intervals on up the pond area until the low point of the last section is 2.1. Obviously, then, this completes the survey up to this 2.1 level. By plotting each of the cross-section lines we can see what the depths of the pond would be at every ten foot point over the area. By connecting the position of each of the 2.1 figures on one diagram we have a picture of the area of the pond.

These points could be run out directly from the ends of the dam without measuring all the intermediate depth points if one wished. This would be

quicker but then the depth conditions would not be accurately known. The pond outline would look like this:

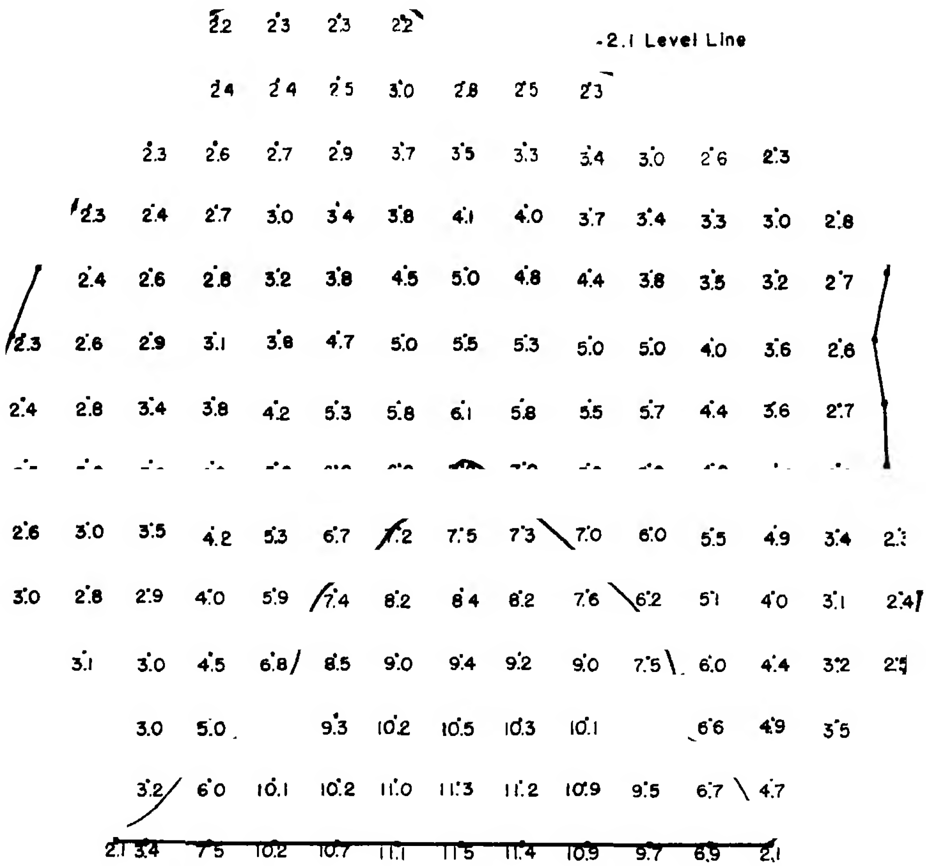


FIGURE 2. Topographic survey of proposed pond area, showing levels of natural ground at ten-foot intervals (compared to water line at 2.1 feet). Area below "A" line will become shallower due to fill. Area within "B" line is deepest, being over five feet prior to any excavation.

The area of the pond can be quickly estimated from the picture. Each square equals one hundred square feet. It is 16,600 square feet or .38 of an acre in this case. Now we should figure out the amount of fill required if the dam is made along the first cross-section line.

At this point a very important decision must be made; namely, what slopes will be built on each side of the dam. On the lower side it will be two to one;

that is, two feet of horizontal distance for each foot of vertical rise. Only when the fill material is of a sort that slides very easily, like sand, does this slope need to be built more gradual. The upper or pond-side slope requires more attention though. If the fill material has a very high proportion of clay it may safely be built to the two to one dimensions. But if it is loamy or silty or with any sand or gravel in it, this slope should be broadened out to 3 to 1.

To estimate volume of fill we must first figure out the *average* cross section area of the dam. To do this we take a cross section of the dam at each of our measured points between the ends. Such a cross section at our lowest position, the one that figured 11.5, is shown on Figure 3 and is worked out as follows:

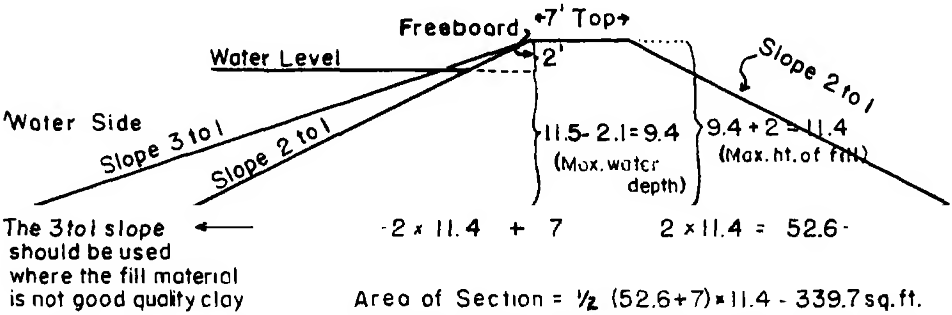


FIGURE 3. Cross-section of fill at lowest ground level, showing computation of its area. This is needed to estimate the volume of dirt in the proposed dam.

Height = 11.5 minus the 2.1 level of the end point, which we are tentatively calling the water level. This is 9 4. However, we must add the extra height of dam that lies above the water level. This we call the *freeboard* and it should be 2 feet. Thus the full height is 9.4 plus 2 or 11.4. The *width* of the top of the dam must be decided now. It should ordinarily be about 7 feet. Now let us assume that our fill material is good clay and we are to use a 2 to 1 slope on each side.

The area of the section, a trapezoid, is one-half the total of the top and bottom multiplied by the height,

$$\text{or Area} = \tfrac{1}{2}(7 + 52.6) \times 11.4 \text{ or } 339.7 \text{ square feet.}$$

(The 52.6 length of the base comes from 2 × 11.4 — the 2 to 1 slope ratio — on each side plus the 7 foot center.)

The other sections figure out as follows, from left to right: 44.1; 161.3;

PLATE 1. A good pond site. It has a flat bottom with sharply rising banks on the sides. The lower end should be as narrow as possible to reduce cost of construction.

274.7; 298.9; 319.0; 339.7 (the one figured above); 334.5; 308.9; 251.5; 131.8. These added together and divided by 10, as there are ten of them, give us 246.4. This is the *average* cross-section. The length between the end (2.1) points is 105 feet. Extended to the end points two feet above water level makes the length 110 feet. By multiplying the length by cross-section, or 110 × 246.4, the volume figures 27,104 cubic feet. Since the usual measure for earth moving jobs is cubic *yards*, we divide this figure by 27. This gives us 1,004 cubic yards for the estimate of fill to build the dam up to this level on the first line measured.

By studying the slopes above the first-tested dam area and around the flood line first checked (the 2.1 level) one can judge whether or not a slight shift one way or the other would bring improvement in area, depth or economy of dam size. In the case we have used, the first guess as to dam location and water level appears to have been about right. A fill of 1,000 yards for a pond of almost four-

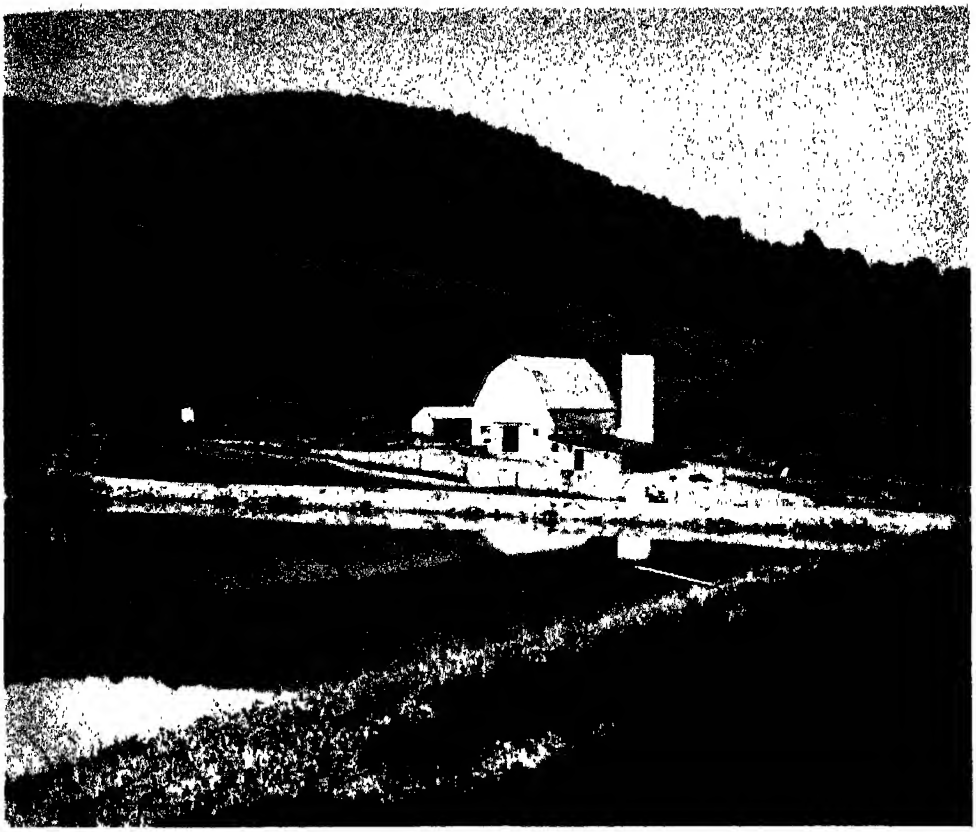


Plate 2. Ponds are most useful when close to the farm buildings. Water from this pond flows by gravity into the barns.

tenths acre is reasonably economical and probably as moderate as could be devised for this area.

This brings up the question of size and depth needed for fish management. First as to size. The smallest pond that is worth bothering with is about one-fourth acre or maybe just a little smaller Good results have been gotten from some ponds as small as one-eighth acre, or about 75 feet square. At least one-quarter acre should be planned, though, if at all possible. The very small ones are more difficult to keep in proper fish balance and, of course, can produce only a rather small quantity of fish

How *large* a pond can be managed successfully by intensive methods is not known for sure. But it is far larger than the home-size pond — at least 100 acres. For farm use, large ponds are not necessary. A one-acre pond may be considered as about the ideal "family size" pond; that is, producing enough fish for home use.

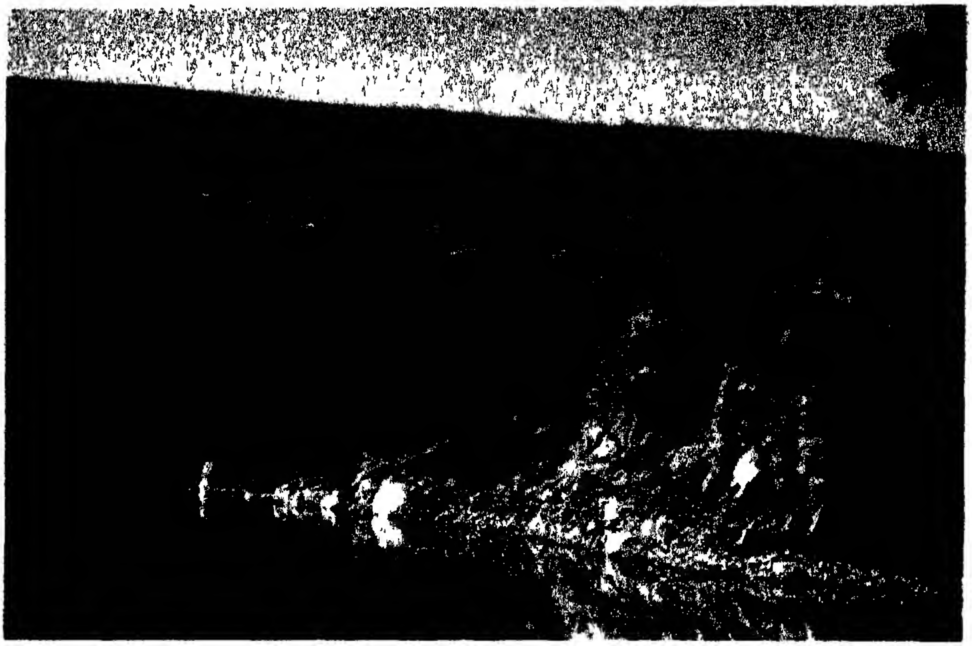


PLATE 3 Abandoned quarries and mining pits can often be developed into good fish ponds Top photo shows an old stone quarry, and below a sealed-off cut in a soft coal strip-mining area These ponds should be tested to make sure that chemical pollution has not made the water unfit for fish

PLATE 4 New ponds should have all woody plants removed before filling with water Some of the trees in the back part of this pond will die anyway, should be removed

PLATE 5 Pond built on a site cleared from a woodland Trees were removed for at least twenty feet back of the water edge.

PLATE 6 Pond watershed should have no erosion Proper soil conservation practices will prevent silt from damaging the pond The contour strip-cropping on the far slope helps to prevent erosion on tilled land

Larger ponds will require greater fishing effort than can ordinarily be given by the family, so, unless you plan to have plenty of help in the fishing, keep your pond moderately small

The depth is very important, but of most concern in cold or dry regions Under any circumstances, at least six feet of water is needed in part of the pond — say one-fifth to one-fourth of its area This assures enough volume of water so that winter ice or drouth evaporation will not reduce the pond in size enough to hurt

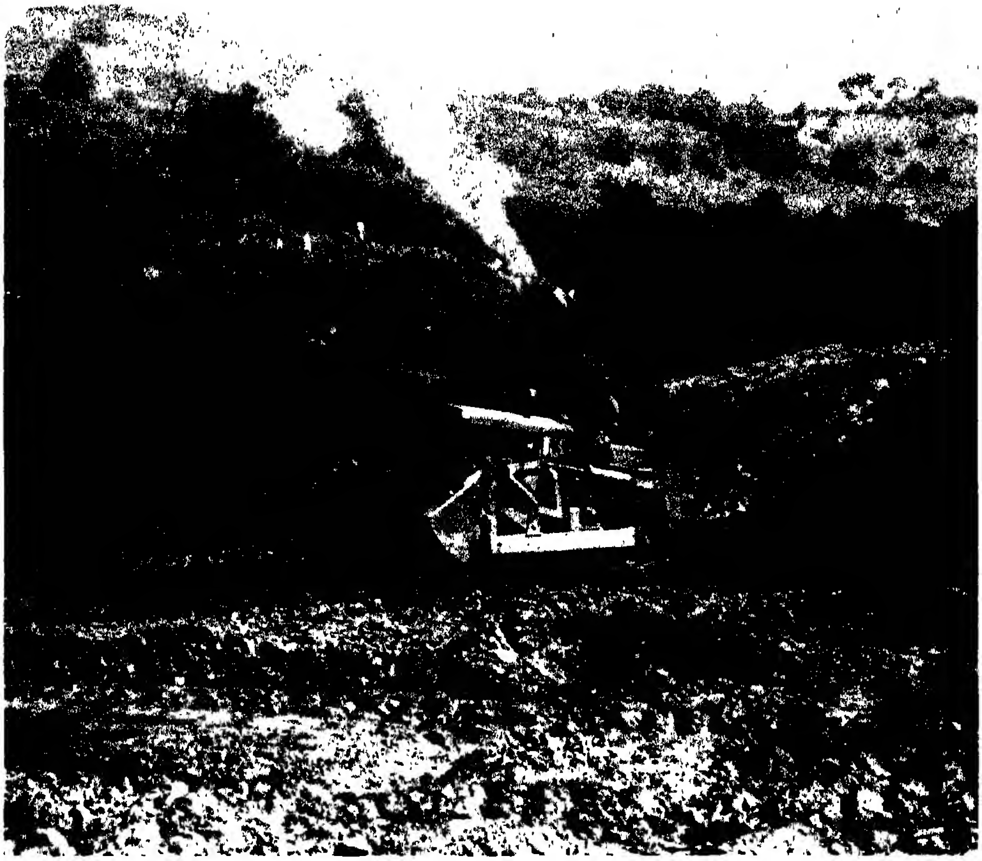


PLATE 7. Pond basin being cleared of brush by bull-dozing and burning (upper center). "Clam-dozer" removing sod to one side in foreground. This machine combines the advantages ot the bull-dozer and power shovel with its hydraulically-controlled bucket-blade on front

the fish. In regions where seasonal drouths are apt to lower the water level a foot or more, extra depth is needed to offset this loss. In northern regions where winter ice regularly exceeds a foot in thickness, extra depth is necessary to balance the lowered water level In the Pennsylvania-Ohio-Missouri zone, ponds of seven to eight feet depth are usually safe. In mid-New England-New York-Michigan, ten feet in the deeper portion is safer, and in the coldest areas along the Canadian border, depths of twelve to fifteen feet are recommended

OTHER FACTORS IN LOCATING THE POND

So far we have considered the soil, water supply, and topography requirements of the pond. These are the considerations that *must* be met if the pond is to be a success. In looking over your land you may find two or more places that meet these essential conditions. Then the decision of where to build the pond may well rest on other factors.

There are several other features that a pond location can have to advantage. Its nearness to the home buildings is very important. Ponds close to home are a source of water for fire-fighting in an emergency. There are many uses for water around the barns; drinking water for animals, garden irrigation and so on. But from the fishing standpoint it is important just for convenience sake. When the pond is easy to reach it will be fished more.

Often ponds will need to be located conveniently to some particular use, as in pasture for livestock water, or near orchards for spray water.

Ponds should not be placed in locations where their failure would endanger life or public property. Avoid places where uncontrolled silt comes in. Fish cannot be grown in water contaminated by poisons such as mine acids, and many industrial wastes.

Be sure that your proposed pond will not violate any state laws. If you are in doubt as to what these laws may be, your state wildlife agency can direct you to the correct source of information.

3

BUILDING THE POND

IN the previous pages we discussed the location of a pond. Before we talk about actually *building*, it should be emphasized again: be *sure* the location chosen is a good one, as good as can be found on your land. If there is doubt in your mind, seek expert advice.

The design and construction of the dam also require technical skill. Unless you are yourself a qualified engineer, be sure to get one to help you. A man who is experienced in planning and supervising construction of earth-fill dams is needed.

DESIGN FOR A DAM

Insist upon having a written plan for your dam with working drawings, before building begins. With a carefully planned blueprint, there is less chance for mistakes to happen

The beginning of our plan is the notes made when deciding the location for the pond. The height of the dam at various places, and its length are easily figured from Figure 1. But since these levels were only carried to the proposed water level, we must extend them on each end to a level two feet higher. This takes care of the "freeboard" — the height of the dam above the water Since the water level on the survey notes was at 2.1, our dam top will be at 2.1–2.0 or 1 foot. For all practical purposes this is the zero for our instrument set-up. Our

completed lengthwise dam section will then appear as in Figure 4. The maximum height of dam is 11.4 feet, the total length along the top is 110 feet.

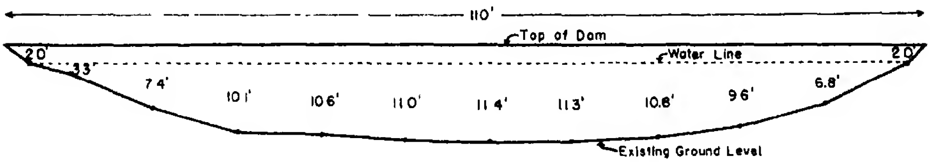


FIGURE 4. Lengthwise section of dam showing height of fill at ten foot intervals, measured each way from the lowest ground level.

In this sample problem we have assumed that the fill material is a good quality clay. This enables us to plan for a two to one slope on both sides of the dam — see Figure 3. Had our soil been only a fair to poor quality of fill material it would have been necessary to design a three to one slope on the water side of the dam. This would, of course, increase the number of cubic yards of dirt needed and raise the cost accordingly.

The next part of our design begins with Figure 3 — the cross-section. To it we add two features: the core of the dam with its footing; the drain pipe. Now see Figure 5.

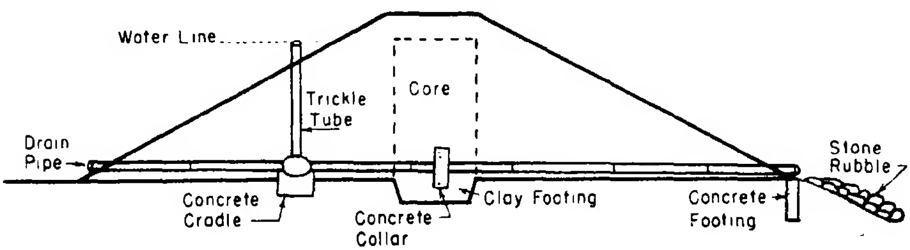


FIGURE 5. Cross-section of the Dam, showing core with its footing, and the trickle-tube and drain pipe.

A core is an impervious column of clay in the center of the dam. If the material that composes the whole dam is itself impervious to water then, of course, we do not need a core. But if the dam material permits any infiltration of water,

then we must seal it with a center section of clay. For ease in construction, this core should be as wide as the machinery being used to build it — usually about six feet but at least four. It should be as high as the water level of the pond.

Beneath the core, or under the center of the dam if there is no core, we should always develop a tight footing. This is merely an extension of our impervious core *downward* to an impervious base. Its purpose is to prevent leakage *under* the dam. How deep this footing is dug — and filled later with clay — depends upon the soil at the dam site. It should be dug down until a clay layer is reached that will not leak. Sometimes this merely requires removal of the topsoil — only a foot or so — and under other less favorable conditions it may require a ditch several feet deep.

THE TRICKLE TUBE AND DRAIN PIPE

The drain pipe is a highly desirable feature of a good pond. It is not essential to the building of a pond but if omitted it will almost certainly be missed with regret later on. For one reason or another it is often desirable to drain a pond; for re-establishing a fish balance, removal of silt, or other purpose. Hence it is wise to build in a drainage system from the start.

There are many ways this can be done but for present purposes of designing the dam, it can be reduced to an inverted "T" shaped pipe with the vertical arm controlling the water level, and connecting to the horizontal arm through a T-joint placed below a point off shore The distance of the trickle tube off shore depends upon whether the machinery used in laying the fill can be maneuvred around the pipe. If not, the pipe must be placed near the end of the drain pipe at the base of the fill. The T-joint should have a concrete cradle two feet deep to support it. The horizontal section runs through the dam. One or more concrete collars should be poured around it inside the dam to prevent seepage along the pipe. A splash base of stone rubble should be laid on the ground beneath the outlet end of the pipe to avoid cutting a gully. A concrete footing under the end, down to frost line, is very desirable.

The drain pipe should be laid at the lowest level in the construction area. These features are shown in Figure 5.

The drain pipe should also serve to carry off the *normal* outflow of water

from the pond. In this way it is also known as a "trickle tube." The size pipe necessary to carry off the constant outflow of water depends, of course, on the amount of that flow. If it is negligibly small it may need only a one or two inch pipe from the water surface down to the horizontal pipe. But if the drainage area is several acres, or a continually flowing spring brings in much more water than is evaporated, it will need to be somewhat larger. For drainage areas of 20 to 40 acres, an 8 inch pipe is recommended, for 40 to 100 acres drainage use a 10 inch pipe and up to 150 acres use a 12 inch pipe.

A solid pipe is the best type to use, either cast iron, corrugated metal, or well casing. Vitreous bell tile or concrete pipe can be used but is more susceptible to breakage. If it is used, the horizontal pipe from T-joint to discharge end should be laid in a concrete cradle poured in the pipe ditch at least four inches below the pipe. When tile or concrete pipe is used, both ends of the horizontal pipe should be encased in concrete and all joints sealed with mortar. In all cases one to three concrete collars should be poured around the pipe at evenly spaced intervals to prevent seepage. These collars should be six inches thick and should extend at least a foot around the pipe on all sides.

An alternative method for building the drain pipe and trickle tube is to use two independent pipes. Each is horizontal, the drain pipe laid as above but without the T-joint, the trickle tube running through the dam at water level. (See Plate 10.) When this method is used, the trickle tube must be extended down the outside of the fill to empty at the base

EMERGENCY SPILLWAY AND OUTLET

Now we have one more point of general design to consider — the *emergency spillway*. This is a surface drainageway or water course that will carry off surplus water in periods of heavy rain which the trickle tube cannot handle. As the trickle tube outlet is always large enough to care for normal water flow, the emergency spillway, as its name implies, comes into use only in periods of unusually high water. But it is a necessary safeguard for all ponds except those whose water is obtained by piping in water from a by-passed stream or those on very small watersheds. Without the provision of this high-water safety valve, the whole dam may be lost by overtapping in some sudden summer cloudburst.

The emergency spillway, or flood outlet, must be placed around one end of the dam in hard ground. (See Figure 6.) It should never be in the dam itself unless the owner is willing to stand the expense of a concrete or masonry overfall structure. But even apart from the extra expense, these structures are often unsatisfactory and frequently cause failure of the dam and loss of the pond. They are not necessary *provided* the pond is properly located, and provided too that the slope around one or other end of the dam will permit the building of a vegetated waterway outlet. It should be placed on the side having the most gradual slope up from the draw to top of dam. Its cross-section should be large enough to carry without overflowing all water that might fall in the most intensive rain (or snow run-off) that might be expected within a fifty-year period.

To find out how big to make this spillway, we must calculate maximum discharge of water that might normally occur in the fifty-year period. This we

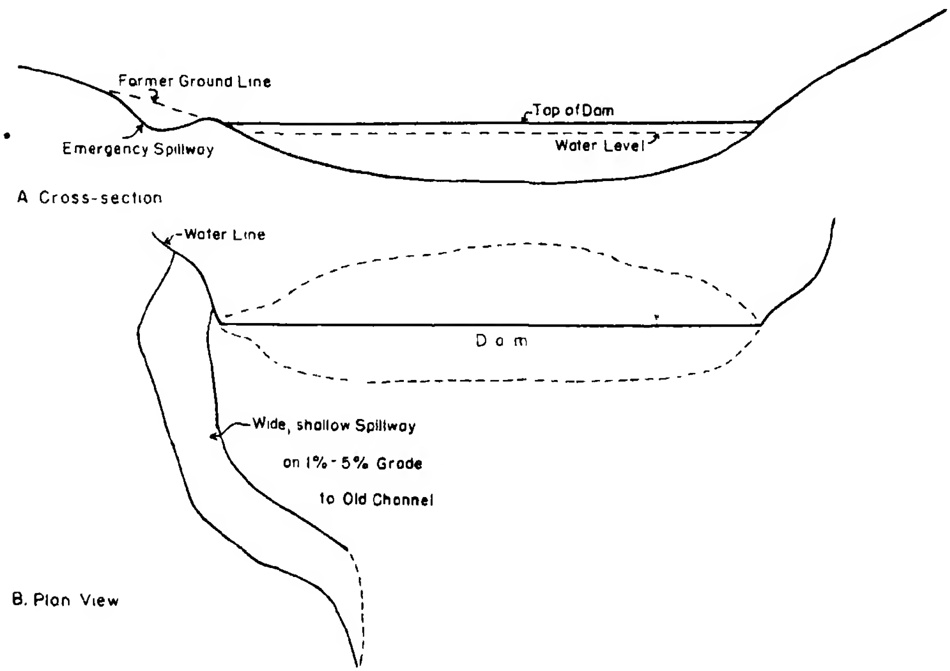


FIGURE 6. Emergency Spillway.

call "run-off" and its determination requires some simple arithmetic. Let us represent run-off by the letter "Q."

Now, the engineers have figured that Q equals the product of three factors: (1) A coefficient which is the ratio of the rate of run-off to the rate of rainfall. This depends upon the land cover and we will let "C" stand for it; (2) the rainfall intensity in inches per hour, or approximately cubic feet per second per acre. This factor varies in different parts of the country according to rainfall conditions. We will let "I" represent it; (3) the watershed area, in acres. Let's call it "A."

Thus, $Q = C \times I \times A$ is our formula.

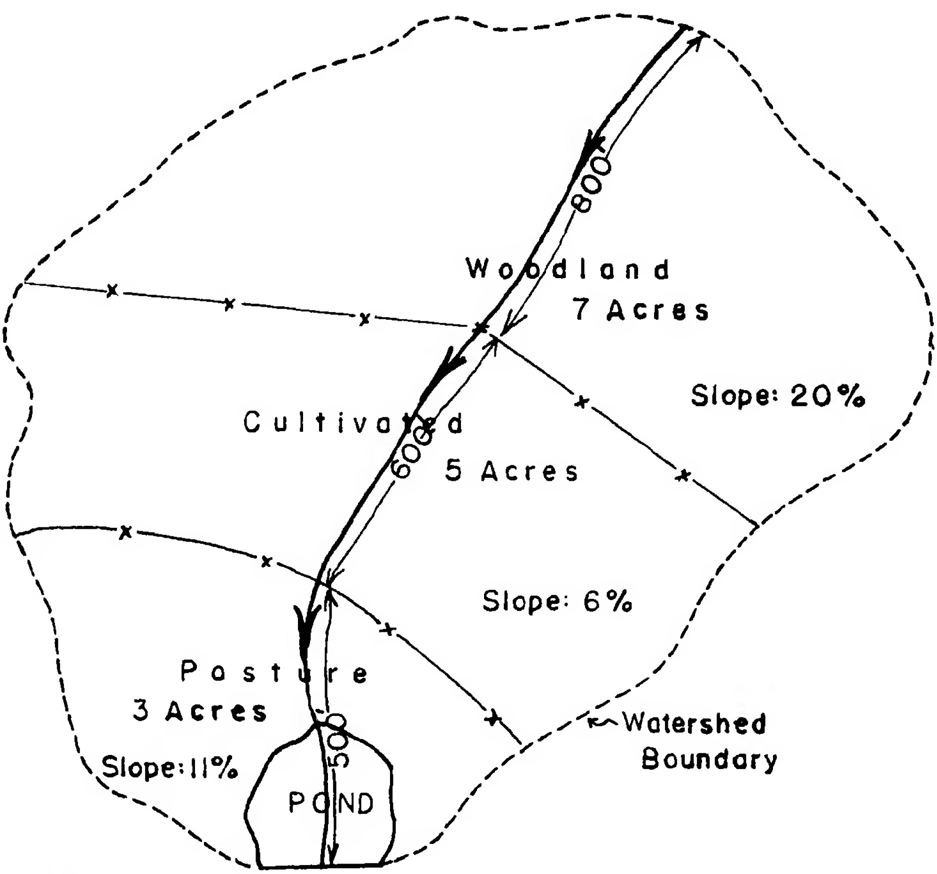


FIGURE 7. Pond watershed map, showing types of vegetative cover, slopes, and distances water must travel to reach pond.

As we said above, C depends upon the cover on the watershed above our pond. Thus we must have a fairly accurate map of the area that drains into the pond, showing the acres of cultivated land (assumed to be under erosion control), pasture and woodland. For our pond it might look something like Figure 7.

Our watershed is composed of 7 acres of woodland with an average slope of 20%, 5 acres of cultivated fields where the slope averages 6%, and 3 acres of 11% sloping pasture land. In Table 1 we have the standard figures for "C" under various cover and slope conditions. From these two sets of figures we may then derive the following calculations for our value of "C," the run-off coefficient.

Cover	*Acres*	*Area %*	*Slope*	*Table 1 "C" Value*	*Weighted Value (column 3 times column 5)*
Woodland	7	47	20%	.2	.094
Pasture	3	20	11%	.4	.080
Cultivated	5	33	6%	.6	.198
	15	100%			.372 (total)

Thus our C = 0.37 (dropping the 3d decimal).

The next figure we must get is the value of "I," the rainfall intensity. This requires that we have dependable data on rainfall for the part of the country where the pond is to be built. This information has been worked out by

TABLE 1. STANDARD "C" VALUES (after C. E. Ramser)

Land Cover	*Slope*		
	Moderate 5–10%	*Hilly 10–30%*	*Steep 30–40%*
Woodland	.2	.2	.3
Pasture	.35	.4	.6
Cultivated	.6	.7	1.0

hydraulic engineers and put in the form of tables and charts so that we may easily make use of them. The facts about our own pond have to be applied to two tables to get the value of "I."

First we need average values of the velocity of water running off the land under various slope and cover conditions. Obviously, the steeper the slope and

poorer the cover the faster the water will run off. These average figures are given in Table 2.

TABLE 2. AVERAGE VELOCITIES OF RUN-OFF FOR VARIOUS CONDITIONS OF SLOPE AND COVER (After Ramser and Horton)

Slope in Per Cent

Cover	0–4	4–8	8–12	12–15	15–20	20–25	25–30
Woodland	1.0	2.0	3.0	3.5	4.0	4.5	5.0
Pasture	1.5	3.0	4.0	4.5	5.0	5.5	6.0
Cultivated	2.0	4.0	4.5	5.0	5.5	6.0	6.5
Pavement	5.0	12.0	15.5	18.0			

From this table we find that our woodland, having a 20% slope, has a run-off velocity of 4.0, our pasture that has a slope of 11% has a velocity of 4.0, and the cultivated land sloping 6% has a velocity of 4.0.

Now from these velocities, and the measurement of greatest distance the water will travel over each type of cover, we may get the *time of concentration.* This uses the simple formula time $= \frac{\text{distance}}{\text{velocity}}$. We take the three distances from our survey map and we get the following: $t = \frac{800}{4} + \frac{600}{4} + \frac{500}{4} = \frac{1900}{4}$ seconds or 8 minutes, approximately. Thus, on the watershed above our pond, the water requires 8 minutes to flow from top to bottom.

With this knowledge, and the fact that we are to design the spillway to care for a maximum rain of fifty-year frequency, we may now turn to Table 3 to find our value of "I." Since this varies geographically, let us assume our pond is in Pennsylvania. (Table 3 is furnished in detail for the northeastern states only. The same figures for other sections of the United States may be computed from charts in Figures 8, 14, 20, 26 and 32 of United States Dept. Agriculture Misc. Pub. No. 204, *Rainfall Intensity Frequency Data*, by D. L. Yarnell, published in 1935.)

It is quickly evident that $I = 7.6$.

Let us now go back to our first formula, $Q = C \times I \times A$. We have $C = 0.37$, $I = 7.6$, and A, the area of the watershed, is 15 acres. Hence $Q = 0.37 \times 7.6 \times 15 = 42.18$, or 42 cubic feet per second.

TABLE 3. INTENSITY FREQUENCY DATA (Yarnell)

Values of "I" for different time intervals to be used in the Rational formula Q = C.I.A.

I = inches per hour

Frequency

I for 50 Year

Time Min.	*Maine*	*Vermont and* N. H.	*Conn. Mass.* R. I.	*New York*	*Pa.* W. Va.	*Md. Del.* N. J.
2						
4	8.0					
6	7.5	7.2	8.2	8.0	8.1	
8	7.1	6.7	7.3	7.4	7.6	8.2
10	6.5	6.3	6.8	6.9	7.2	7.6
12	6.1	5.9	6.5	6.5	6.8	7.2
14	5.6	5.6	6.2	6.2	6.4	6.8
16	5.3	5.4	5.9	5.9	6.1	6.5
18	4.9	5.1	5.7	5.5	5.8	6.2
20	4.6	4.9	5.4	5.3	5.6	5.9
22	4.4	4.7	5.2	5.1	5.3	5.7
24	4.2	4.5	5.0	4.9	5.1	5.5
26	4.0	4.3	4.8	4.7	4.9	5.3
28	3.9	4.1	4.6	4.6	4.7	5.2
30	3.8	3.9	4.5	4.4	4.5	5.0
32	3.7	3.8	4.3	4.3	4.4	4.9
34	3.5	3.7	4.2	4.2	4.2	4.7
36	3.4	3.6	4.0	4.0	4.1	4.6
38	3.3	3.5	3.9	3.9	4.0	4.4
40	3.2	3.4	3.8	3.8	3.9	4.3
42	3.2	3.3	3.6	3.7	3.8	4.2
44	3.1	3.2	3.5	3.6	3.7	4.1
46	3.0	3.1	3.4	3.4	3.6	4.0
48	3.0	3.0	3.3	3.4	3.5	3.9
50	2.9	3.0	3.2	3.3	3.4	3.8
52	2.8	2.9	3.1	3.2	3.4	3.7
54	2.8	2.8	3.0	3.1	3.3	3.6
56	2.7	2.8	3.0	3.0	3.2	3.5
58	2.7	2.7	2.9	3.0	3.2	3.5
60	2.6	2.7	2.9	2.9	3.1	3.4

We are now ready to figure how large our spillway section must be. As it is a question of providing enough room for water to pass through, one can readily see that a variety of dimensions can be used so long as their product gives the needed area. Thus if we needed 20 square feet, it could be provided by a channel 5 feet wide and 4 feet deep, 10 feet wide and 2 feet deep, or 20 feet wide and 1 foot deep. In so far as the slope of the ground will permit, the widest and shallowest spillway possible should be designed.

Turning to the body of figures in Table 4 and finding the places where our 42 c f.s. falls, we find the following possible dimensions for our spillway:

3.5 feet deep by 2 feet wide;
2.0 feet deep by about 5 feet wide;
1.5 feet deep by about 7 feet wide; or
1.0 foot deep by about 13.5 feet wide.

If the slope of the ground where we are to build the spillway is gradual enough, the latter dimensions should be used. If it is too steep, take the next shallowest design, or the next, until you find the one that can be dug without going too deep into the hillside Rarely is it wise to use a depth greater than 18 inches, however

Having figured the size of the opening of our emergency spillway around one end of the pond, we still must figure the details of the shape and size of the outlet channel that carries the water from the opening beside the dam down to the bottom of the drainage channel below the dam

We begin by cutting the opening of the spillway so that its bottom is *six inches* above the level of the trickle tube Thus the water will have to back up six inches deep over the pipe outlet, making the whole pond six inches deeper, before it starts flowing out the emergency spillway

It is desirable to make the grade of the outlet channel as gradual as possible to prevent the water cutting, causing erosion, and starting gullies. On the other hand, the more gradual the grade, the longer will be the channel to get down to the old ground level below the dam. And the longer the channel the more it will cost to build But no matter how desirable it is to carry the water down the channel gradually, the grade must be steep enough to carry the water off without it backing up and overflowing the sides of the channel

To find out what velocities are needed for any given run-off and spillway section, we need to refer to charts developed for this purpose. One chart is made for each spillway depth. Let us check the chart for channels having a depth of 12 inches. In our case, we *could* use a 12-inch channel 13.5 feet wide. (See Figure 8.) But when we run a line *up* on the chart from the 13.5 foot width point, and *across* from the 42 c.f.s. value for A, they cross on the chart line for S = 7% (S = slope). This means that it would be necessary for us to build a 7% grade in our outlet to carry off the peak fifty-year flow of 42 c f.s. if we built the

APPROXIMATE DISCHARGE CAPACITY IN CUBIC FEET PER SECOND OF BROAD CRESTED SPILLWAYS FOR USE WITH EARTH DAMS

By C. E. Ramser

Head on Crest of Spillway Feet	*Length of Spillway in Feet*														
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
0.5	2.3	4.5	6.8	9.1	11.3	13.6	15.8	18.1	20.4	22.6	24.9	27.2	29.4	31.7	33.9
1.0	6.4	12.8	19.2	25.6	32.0	38.4	44.8	51.2	57.6	64.0	70.4	76.8	83.2	89.6	96.0
1.5	11.8	23.5	35.2	47.0	58.8	70.5	82.3	94.1	105.8	117.6	129.3	141.1	152.8	164.6	176.4
2.0	18.1	36.2	54.3	72.4	90.5	108.6	126.7	144.8	162.9	181.0	199.1	217.2	235.3	253.4	271.5
2.5	25.3	50.6	75.9	101.2	126.5	151.8	177.1	202.4	227.7	253.0	278.3	303.6	328.9	354.2	379.5
3.0	33.3	66.5	99.8	133.0	166.3	199.5	232.8	266.0	299.3	332.5	365.8	399.1	432.3	465.6	498.8
3.5	41.9	83.8	125.7	167.6	209.5	251.4	293.4	335.3	377.2	419.1	461.0	502.9	544.8	586.7	628.6
4.0	51.2	102.4	153.6	204.8	256.0	307.2	358.4	409.6	460.8	512.0	563.2	614.4	665.6	716.8	768.0
4.5	61.1	122.2	183.3	244.4	305.5	366.6	427.7	488.8	549.8	610.9	672.0	733.1	794.2	855.3	916.4
5.0	71.6	143.1	214.7	286.2	357.8	429.3	500.9	572.4	644.0	715.5	787.1	858.6	930.2	1001.7	1073.3
5.5	82.6	165.1	247.7	330.2	412.8	495.4	577.9	660.5	743.0	825.6	908.2	990.7	1073.3	1155.8	1238.4
6.0	94.1	188.2	282.2	376.3	470.4	564.5	658.6	752.6	846.7	940.8	1034.9	1129.0	1223.0	1317.1	1411.2
6.5	106.0	212.1	318.1	424.2	530.2	636.3	742.3	848.4	954.4	1060.5	1166.5	1272.6	1378.6	1484.7	1590.7
7.0	118.5	237.1	355.6	474.1	592.6	711.2	829.7	948.2	1066.8	1185.3	1303.8	1422.3	1540.9	1659.4	1777.9
7.5	131.5	262.9	394.4	525.8	657.3	788.7	920.2	1051.6	1183.1	1314.6	1446.0	1577.5	1708.9	1840.4	1971.8
8.0	144.8	289.7	434.5	579.3	724.2	869.0	1013.8	1158.7	1303.5	1448.3	1593.2	1738.0	1882.8	2027.6	2172.5

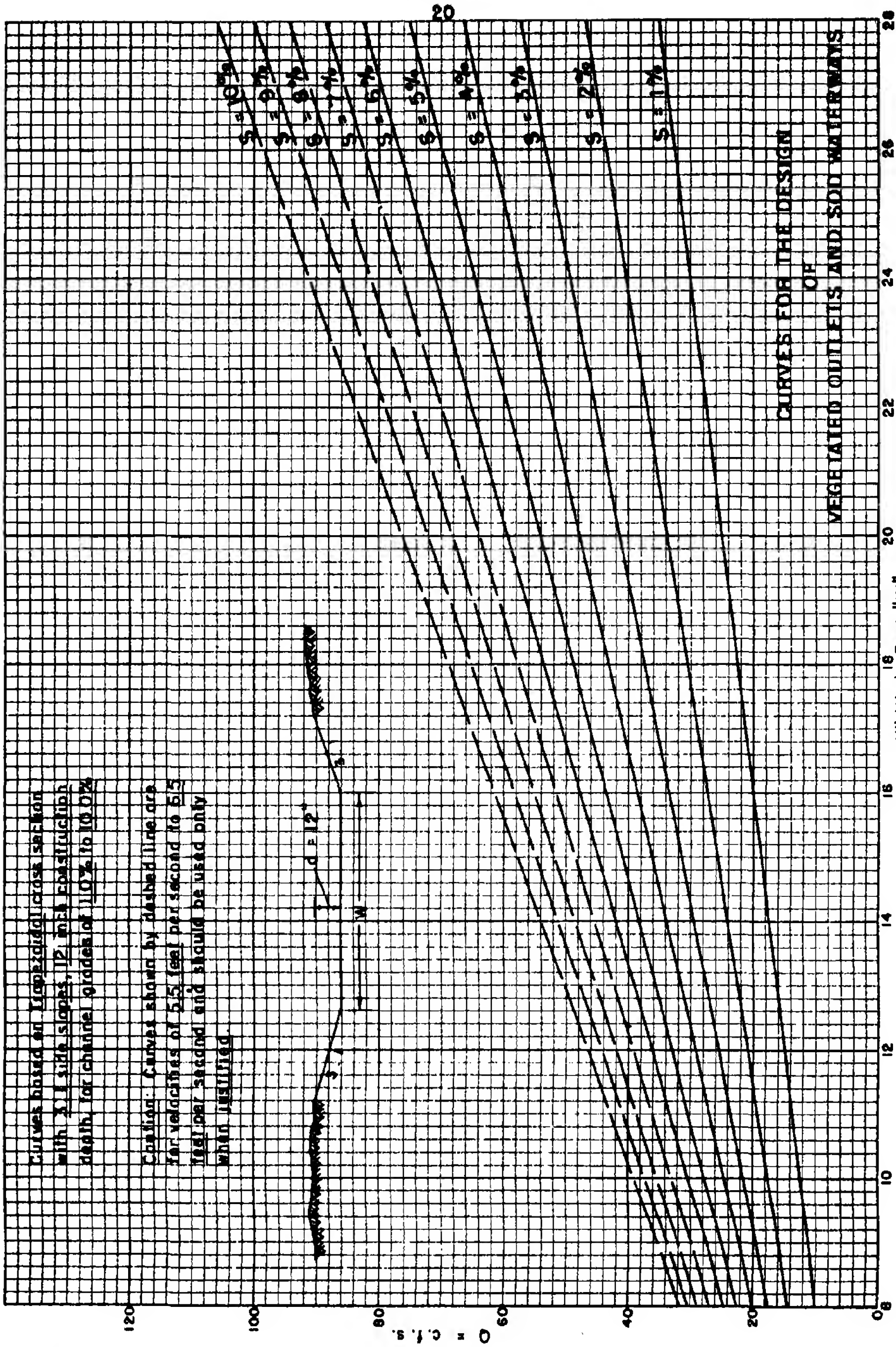
Computed by formula $Q = 3.2\, L\, H^{3/2}$

Where Q = Discharge in cubic feet per second

L = Length of spillway in feet

H = Head of water on crest of spillway in feet

Table 4



CURVES FOR THE DESIGN OF VEGETATED OUTLETS AND SOD WATERWAYS
Curves based on trapezoidal cross section with 3:1 side slopes, 12 inch construction depth, for channel grades of 1.0% to 10.0%
Caution: Curves shown by dashed line are for velocities of 5.5 feet per second to 6.5 feet per second and should be used only when justified.
d = 12"
W
S = 10%
S = 9%
S = 8%
S = 7%
S = 6%
S = 5%
S = 4%
S = 3%
S = 2%
S = 1%
Width in Feet "W"
Q = c.f.s.

Figure 8

channel 1 foot deep and 13.5 feet wide. Experience has shown that it is very difficult to maintain an outlet this steep without gullying and constant repairs. That is why the graph line S = 7% and those higher are dashed, and a caution note given that they should be used only when *justified*. The only justification is heavy soil that holds together well and a willingness to make frequent repairs. But it probably will be better to make the channel a little deeper and avoid this trouble. Going back to Table 4 we find that a 15-inch depth channel would need to be about 10.5 feet wide to carry 42 c.f.s. Now checking the 10.5 feet line and the 42 c.f.s. line on Figure 9, the chart for channels 15 inches deep, we find that the grade, S, would need be only 3%. This is well within the margin of safety.

Hence we may design the outlet channel on a 3% grade, with a flat bottom 10.5 feet wide, 3 to 1 side slopes giving a 15-inch depth

BY-PASS ARRANGEMENT FOR STREAM PONDS

Where a pond can be built in a stream valley and at the same time have the stream kept away from the pond, there is no need for either trickle tube or emergency spillway. This assumes, of course, that the pond is so constructed as to prevent the stream from overflowing into it even in flood time. Such ponds do have to have an arrangement for bringing just the desired amount of water into the pond from the stream.

Water from the stream can be brought into the pond in two ways. Generally the simplest way is to run a pipe of correct size on a straight grade from some point in the stream above the pond level down into the pond. Sometimes this requires a considerable length of pipe, but it generally works out well. A one-inch pipe is adequate for a one-quarter acre pond, a two-inch pipe for a one-acre pond. From these you may gauge the best size pipe for your own pond. A valve should be placed near the inlet end to control the flow.

The second method is to ditch the water into the pond on a slight grade from a point in the stream above pond level. This requires considerable accurate ditch construction in many cases. It works like a mill race and, like the mill race, must take off from the stream so that the ditch and pond will not be subject to floods. The inlet end of the ditch should be controlled by an adjustable wooden gate with flashboards

When water is taken from a stream to maintain a pond, the pipe or ditch should be carefully screened at the inlet end. A double screen is preferred with ditches. One screen should be very fine mesh, about like fly screening. Where two screens are used in ditches a more coarse mesh, say one-half inch, may be used first, with the fine screen down-ditch from it a foot or more

Purpose of the screening is two-fold. Most important is to keep out unwanted fish. It is very difficult to do a good job of managing the fish in a pond if wild fish of various kinds can get in from outside. The second reason is to keep out trash. Sometimes debris will gather on the screen and clog it This should be watched and the screens always kept clean.

CONSTRUCTING THE DAM

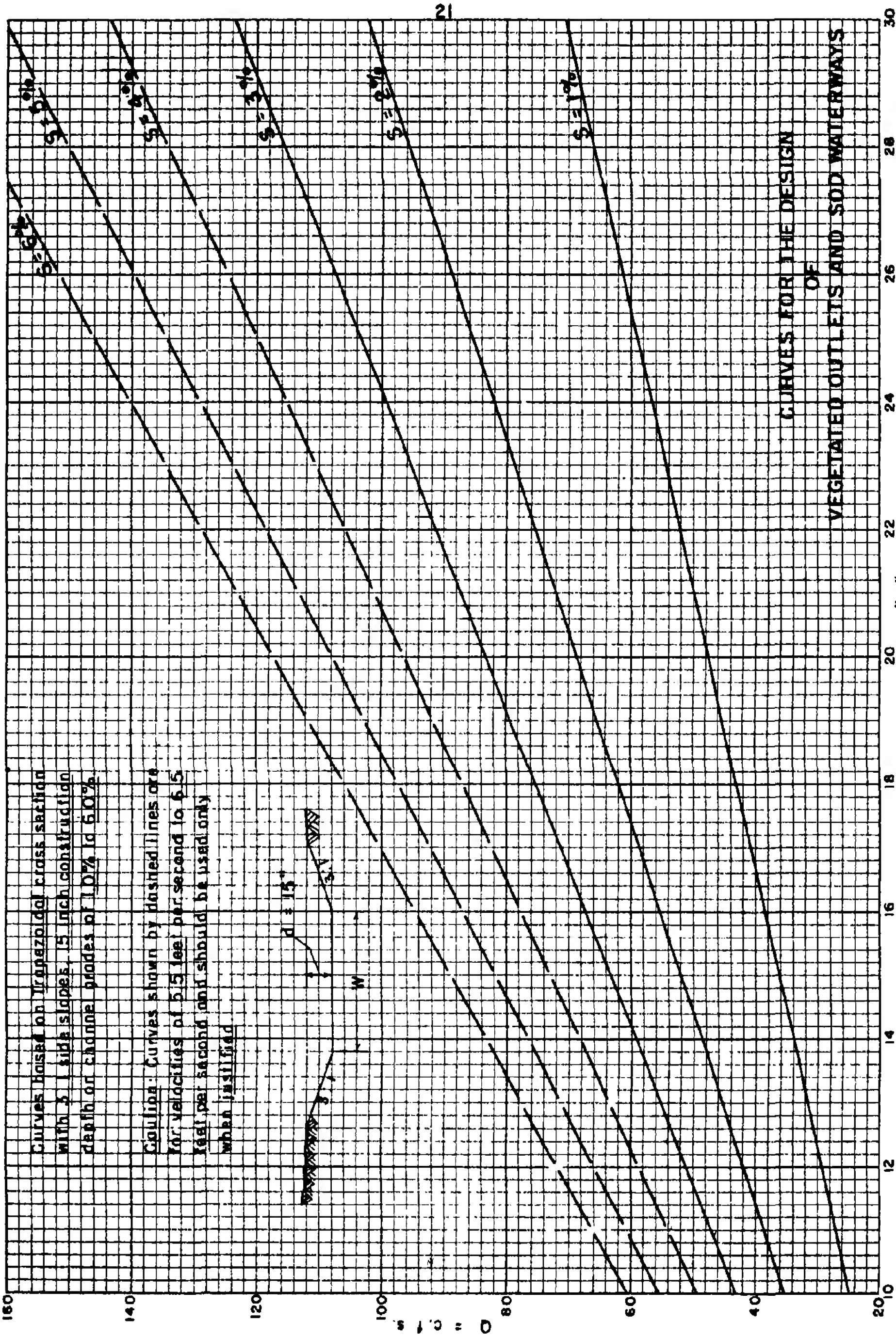
The first step in preparing for construction is to scarify the entire area where the dam is to be All vegetation and topsoil should be cut and scraped off and pushed *downhill* out of the way It is well to pile the topsoil convenient to the dam where it can later be used to top-dress the finished dam It helps greatly in getting a good vegetative cover started

If the soil of the construction area is good clay there need be no further preparation before bringing in fill dirt But where the soil is at all pervious, it is necessary to dig a trench in the center section the full length of the dam to begin the clay core This trench should be about six to eight feet wide, depending upon the type of machinery being used and the convenience in handling it It must be dug deep enough to reach an impervious layer

In some cases where bedrock is close to the surface it may be better to construct a concrete core wall instead of clay In this instance the concrete wall must be keyed well into the bedrock to prevent leaks

The borrow pit — the place where we are to take the fill dirt for our dam — must be located. Preferably it should be in the flood area of the pond. Then it serves a double use: to furnish fill dirt; and to deepen the pond. It is best to take the fill dirt from the center of the pond close to the edge of the construction area if the dirt is suitable

In any case, wherever the borrow pit is, it must be as good quality clay as is available The surface cover and topsoil must be removed from the borrow pit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CURVES FOR THE DESIGN
OF
VEGETATED OUTLETS AND SOD WATERWAYS
Curves based on trapezoidal cross section
with 3:1 side slopes, 15 inch construction
depth on channel grades of 1.0% to 6.0%
Caution: Curves shown by dashed lines are
for velocities of 5.5 feet per second to 6.5
feet per second and should be used only
when justified
d = 15"
3:1
W
S = 1%
S = 2%
S = 3%
S = 4%
S = 5%
S = 6%
Width in Feet "W"
Q = c.f.s.
10
12
14
16
18
20
22
24
26
28
30
160
140
120
100
80
60
40
20

FIGURE 9

too. Never use loose topsoil for the dam. Store it off to one side or below the dam where it can be gotten later for top dressing.

While we are talking about clearing off the surface layers, let us finish it for the whole pond. It is always best to clear all trees, shrubs or rank vegetation from the whole pond area. If this is not done, the woody plants will die anyway. Then the wood decays slowly over a long period of time. This adds tannic acid to the water that makes it very acid. Further, dead plants protruding from the water are unsightly. I recommend that you go even further. Mow the grass and weeds on the pond bed and remove all the clippings. Then, in so far as it is possible, plough under the sod just as if you were going to make a garden there. This helps speed the decay of the plant cover and makes their fertility more quickly available in the water.

Before any fill is placed, the horizontal pipe for the trickle tube and draining system must be installed. It should be placed at the lowest point in the construction area. In our example, it will take fifty-three feet of pipe (see Figure 3). It must always be laid in hard ground, never in fill dirt. A ditch just large enough to take the size pipe being used is dug in order to get a smooth even grade downhill. As the pipe is laid, all joints should be tightly sealed. Plastic-asphalt cement containing asbestos, a fine rich mortar, or bituminous joint compound (poured hot) are suitable for this purpose. After finishing each section, clean the interior with rope or stick and cloth pad. From now on, any spring water coming into the pond area will leave through this pipe.

When the pipe is laid, the two or three concrete collars are next. Simple wood forms are built to make a box about two to three feet square and six inches thick. Then the concrete is poured in them The lower portion is formed by merely digging out the earth so that the pipe goes through the center of the concrete.

Then dirt is filled in around the pipe and tamped tight so that there will be no "give" when the dam is built on top of it. This is especially important if bell tile is used as it is easily broken if not very tightly packed in.

Once the pipe is in, filling may begin. The fill area is staked out according to our design Dirt is brought in by layers, not over six inches at a time. First fill in six inches of the best clay in the core trench. Pack this down thoroughly and evenly by running over it with tractor treads, dual truck tires, or rollers, or

by hand tamping if necessary. Add clay layers to the core in this manner until it is even with the rest of the construction area.

If all the fill material is of good quality clay we need no longer bother about the core. We just treat the whole fill area the same. But if the main volume of fill dirt is not good, impervious clay, then we must continue to bring in clay to build up the center core. In either case, lay six inches of the whole area at a time; then pack it down tightly before adding more.

In this manner the dam is gradually built up to full height. As each layer is added, its area is smaller than the previous one. Following each added layer, you should check the measurements of height and width to make sure the two to one slope is being built as planned. Then, when the full planned height is reached, the top width should be seven feet. Upon the surface of the dam, now completed to required dimensions, should now be spread a dressing of the topsoil that was originally piled to one side when scraped off the building area. This will offset settling of the dirt and aid in getting a seeding later.

An aid in assuring proper slope is the use of a template for a 2:1 slope. To make the template, use three pieces of two inch wide boards, one two feet long, one four feet long. These two are nailed together at a right angle. The third piece, which will be about four feet six inches, becomes the third side (hypotenuse) of the right triangle. By laying this along the slope with the long side on the ground and the four foot side on top, the slope will correctly be two to one when a bubble level shows the four-foot side to be level.

One caution is needed in handling the equipment on the work area. Keep machinery off the sod where the emergency spillway is to empty. This will save this cover from damage. It will be needed to handle any flood water that might come.

BUILDING THE EMERGENCY SPILLWAY AND OUTLET

Upon completing the dam we turn our attention to the emergency spillway. No delay should be permitted in getting to this job for we never know when a cloudburst may come. Our dam is very vulnerable until the spillway is ready.

Another reason for making the spillway promptly is simple efficiency in using the earth-moving equipment. While it is there on the spot we should use it for all the work it can do.

PLATE 8. Trickle tube built in the fill of a dam. It is connected to the drain pipe with a T-joint.

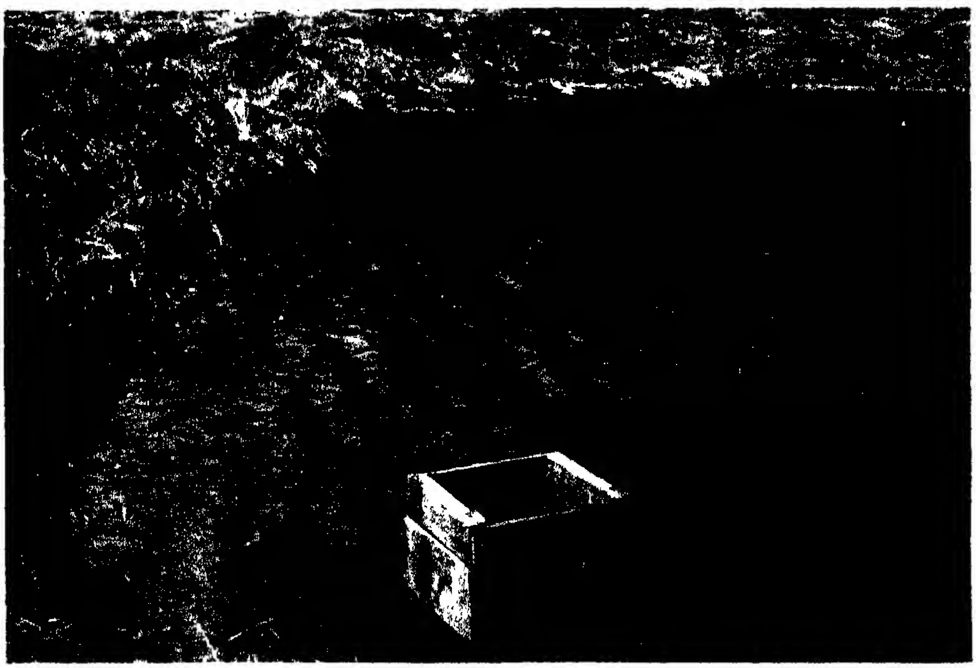

PLATE 9. Screen around top of trickle tube to prevent trash from clogging it.

PLATE 10. The two-pipe drainage and trickle tube system. Top photo shows drainage pipe at low point in pond bottom. Lower photo shows independent trickle tube through fill of same dam.

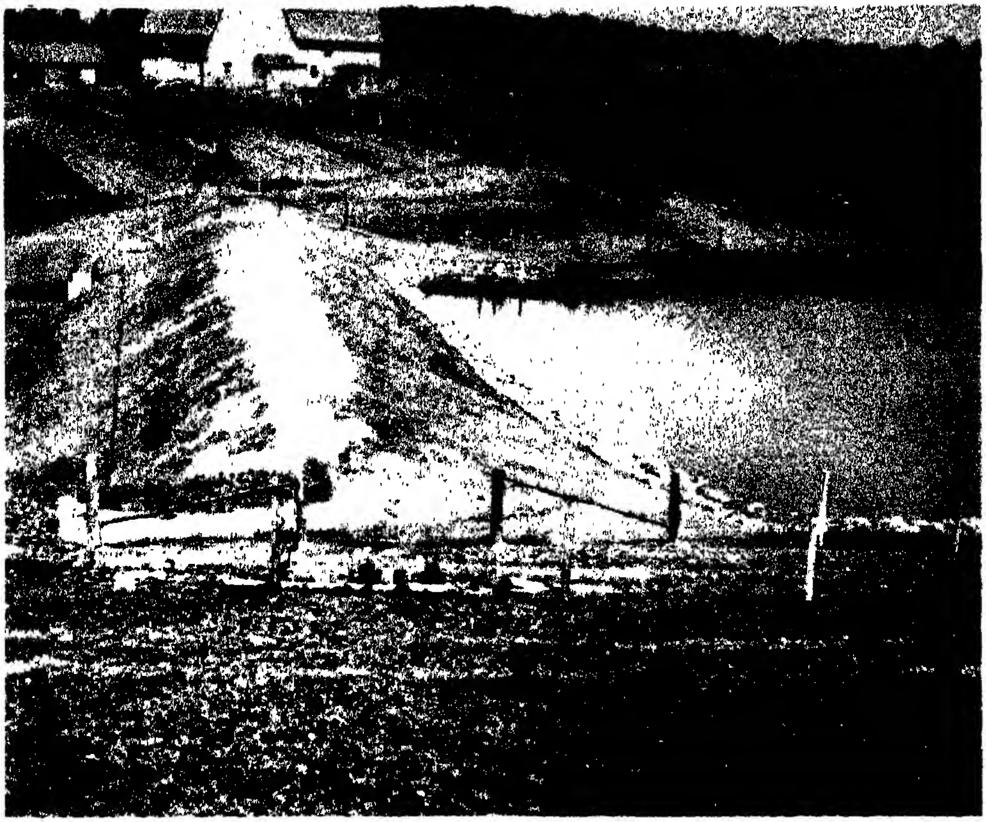

PLATE 11. Pond dam with 2 to 1 slope on lower side, 3 to 1 slope on water side. The emergency spillway is in the foreground, and a cattle-watering tank is below the dam in the distance.

Generally the spillway will require moving some dirt to get the correct channel dimensions and grade. Usually the same equipment used on the dam will suffice although, since this requires digging as much as filling, a plow, grader, or bulldozer blade is needed. Some handwork is almost always needed to smooth up the job.

As topsoil has to be removed to make the cut for our channel it should be carefully saved at one side. Later we will want to top-dress the whole disturbed channel area to help us get a good sod cover. If the sod that we must move is of good quality, it will pay to cut it out in square foot clods, to be relaid later just as is done with lawns.

The details of building the channel depend upon the lay of the ground. Some places must be excavated, others filled in. After roughing the channel out with

PLATE 12. Emergency spillway carrying off flood water after very hard rain Had the spillway not been there the dam would have been lost.

our machine, constantly checking grade, width and side slopes, the job is then smoothed up by hand shovel

We must not forget that even though the emergency spillway may save the dam in case of a quick, heavy rain, the outlet channel itself is also vulnerable until it is covered by a good sod Complete sodding with clods of good quality turf should be applied promptly after construction is finished. Turf-building treatment is also called for, as it is on the dam proper, but we will consider this shortly.

GRADING THE POND MARGIN

One more job remains for our construction machinery As we shall better understand why later, we want to avoid shallow water in the pond as completely

PLATE 13. The flood spillway should be broad and shallow, with a thick, vigorous sod. The wire screen across the entrance was placed temporarily to prevent possible escape of newly-stocked fish.

as possible. Suffice it to say now that shallow water induces the growth of numerous water plants. These, in turn, complicate the maintenance of the proper balance in our fish populations, and often produce a mosquito nuisance.

The first condition for controlling these shallow water plants is to limit the area of shallows. Because the sides of the pond are made of dirt, we cannot have vertical sides which would be ideal. Instead we can grade the margins rather steeply, how steep depending upon the type of soil. For heavy soils that adhere well, a one and one-half to one slope is suggested. To accomplish this, the edges are graded so that the water will be three feet deep four and one-half feet from the water's edge. The bottom is graded evenly from the water's edge to that point.

In most areas, the soil will not be heavy enough to maintain a one and one-half to one slope. Then a two to one slope should be used. Grading the marginal area so that the water will be three feet deep six feet from shore produces this grade.

PLATE 14. A diversion ditch (terrace) is often useful to carry excess surface water away from the pond. The one shown is newly plowed, will be smoothed over and seeded to a grass sod.

This grading should be carried out all around the pond where water less than three feet deep would be found within six feet of the edge. Of course, it cannot always be done completely since spring heads must be allowed to flow in at their natural, easy grade. But except for spring areas, the rest of the edge can be deepened as desired.

The process in deepening is to push the dirt from the shallow areas *within* the pond boundary *outward*. If the volume is not too large it can all be shoved outside the pond edge and then graded back to make a smooth bank. Where the volume of dirt is too large to push very far, that is, in the shallowest areas, it will be better to fill in the edge of the pond area with dirt from farther out. This reduces the size of the pond a little but is better than having useless shallows. Figure 10 shows how this shifting of the dirt is done.

In the spot illustrated, the reduction of the shallow resulted in loss of about three feet of water area.

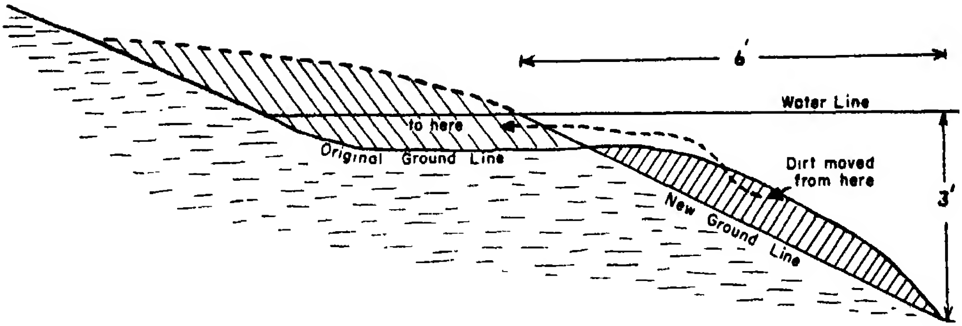

FIGURE 10. Grading shallow pond margins to the desired 2 to 1 slope.

COMPLETING THE TRICKLE TUBE

We have already laid the bottom pipe of our drainage system and normal water flow outlet. This was necessary before we could build the earth fill dam. This horizontal pipe — not *quite* horizontal actually since it has to grade slightly downhill so the water will flow out — runs through the dam from the water side at the deepest point to the lower edge of the downstream side. As we left it, with the inlet end open, any water coming into the pond area is immediately drained out. This is the way we want it to function if ever the pond is to be drained. But this opening must be closed if the pond is to fill with water. Then too, the trickle tube is to control the water level of the pond.

To accomplish these ends we must now arrange to connect the vertical pipe of the system to that already laid. There are many ways to make this connection. One type of structure is illustrated in Figure 5. It can be recommended for general use.

A T-joint has been inserted in the drain already laid in the ground. The side opening of the T is face *up*, and connected to the vertical trickle tube. From the T-joint to the pond end the horizontal pipe may be either iron or tile. Iron is better and can be closed by installing a screw valve at the end. The valve is operated by a key rod long enough to reach above the water surface. If a cheaper method of sealing the drain pipe is desired, tile may be used and the open end plugged with concrete to enable the pond to fill with water. When it is necessary to drain the pond, the end tile is smashed with a long iron rod. Each time

this is done, a new section of tile is placed, resealed with concrete, and the pond fills again. While not as satisfactory as the iron valve method, it does reduce the cost of materials considerably.

A last structure is now needed to protect our vertical trickle tube. This is especially true of ponds that freeze in the winter. The pipe is apt to be broken by moving ice if not guarded. It is also desirable to protect the pipe opening with some sort of mesh cover to keep it from clogging with trash, especially dead leaves in autumn.

Protection of the riser pipe — the vertical section — is easily managed with a simple four-post wood scaffold. The four posts — say two by fours — are driven in at the corners of a square around the pipe. They should protrude a little above the water and be fastened together at the top. Criss-cross braces nailed across each side will help make the structure rigid, if needed.

To keep rubbish from getting into the trickle tube, a strip of one inch mesh chicken wire about two feet wide may be fastened around the scaffold so that it is partly above and partly below the water level. When leaves and other debris clog the wire it should be cleaned off.

WATERING TROUGH FOR LIVESTOCK

Often the farm pond is in a pasture or next to one. The water from the pond may be needed to water the animals. It is a simple matter to connect the outflow pipe of the trickle tube to a tank placed below the dam.

If the flow of water through the pipe is not steady and dependable — especially during the dry summer period when it is most needed — an arrangement can be made to take the water for the trough from a depth of three or four feet in the pond. This can be done either through a one-inch hole connection in the horizontal drain pipe, or by a separate small-gauge pipe through the dam. In either case, the outflow of water must be checked by a valve, else the pond will be drained. This can be arranged by installing a float valve — the type used in a watercloset — in the watering tank. Properly adjusted, it keeps the water level in the tank constantly full, yet never overflows. The valve should be inspected occasionally to make sure that it does not jam and cause undue loss of water from the pond.

4

LANDSCAPING THE POND AREA

ONE of the nicest things about a pond is its beauty. At least it offers an opportunity for developing the loveliest spot on the farm. There's something so fascinating about water! And then when it is enhanced with attractive surroundings it becomes the place where all the family want to spend their spare time.

There are a few essentials about developing the pond area that one should be sure to follow. Then, beyond that, you can give full play to your skill with plants and the many little fixtures suitable for a garden.

TAKING CARE OF THE LIVESTOCK

As many ponds are built in or next to pastures, there will often be the matter of keeping the cattle or other stock under control. Access to the pond leads to trouble if continued long. Cattle, in particular, tend to congregate and hang around the watering place. They trample the pond banks causing erosion and making an unsightly mess. By wading in the water, they tend to keep the pond muddy. This is not good for the fish. We have already discussed the means of providing watering facilities for the stock by piping water from the pond to a tank below. Now the problem is keeping the animals away from the pond itself.

The obvious answer is a protective fence, barbed wire if only cattle or horses are involved or woven wire for sheep or hogs. For those who dislike wire

fences, there are other types made of wood. Personally I favor still a different fence, one that truly blends into our landscaping scheme and contributes its share to the attractiveness of the place — I mean a living fence or hedge.

A plant that serves this purpose admirably is the *multiflora rose.* When planted in a single row one foot apart it develops into a hedge fence that will turn any stock except unringed hogs. Four or five years are required for it to grow, during which time a temporary wire fence will be needed. But once it has developed, it adds the beauty of white flowers in the spring and red fruits all fall and winter while serving as a fence.

In establishing the rose hedge, the line of planting should be ploughed in a double furrow, throwing the soil together in the middle. Then the seedling plants — one year or two year nursery grown — are planted in the middle line. If this planting preparation cannot be done, then each bush should be planted in a hole in the center of a one-foot square from which the sod has been removed. In effect, this means scalping the sod off a planting line one foot wide.

The rose hedge will grow to about eight feet in height. The higher branches arch over gracefully, and little if any pruning is needed. So long as the land on either side has a good sod, or is farmed, the roses should not spread. One thing must be done in getting the planting well started: a careful planting job with no grass or weeds around the roses to slow them up for the first year or two. It might even be well to give them a cultivation or two until they are above the rest of the vegetation.

There are numerous varieties of multiflora rose, including one that is thornless. To serve as a fence, they should be very thorny. But in planning the hedge fence, one must be sure to leave gaps where gates are needed for once the hedge is developed a man cannot pass through it any easier than a cow

A GOOD TURF SURROUNDS THE POND

The second essential in developing the area immediately around the pond is a good turf of sod-forming grasses and legumes. This area should be as nearly like a fine lawn as it can be made. The dam and emergency spillway should all be in sod. The sides of the pond for at least ten feet back from the water's edge, and preferably twenty feet, should also be in grass. This is the playground. It

PLATE 15. Formerly an unproductive gully, this pond is now a scene of beauty.

provides ample room for fishing from the shore without tangling one's fly or lure in too-close bushes. Here you can have a soft, green bathing beach and a cool picnic ground without bother of mosquitoes.

Getting a good stand of grass is often a problem, especially on the dam and portions of spillway and pond margins where the topsoil was scraped off. But it will be recalled that the original topsoil was piled to one side while the dam was being built, and then put back as a top-dressing on the dam when finished. Provided this was carefully done, it should help a lot in getting a good seeding started.

Even with the best of topsoil dressing, it is advisable to treat the bare

areas well before seeding. The application of a pound of manure for each two square feet (that is, ten tons per acre) should be made well ahead of seeding time. Lime adequate to bring the pH up to 6.5 should be applied at the same time. Have the soil tested by your County Agent, or get a test kit and do it yourself. Then follow instructions for the amount of lime needed to raise it from present level to the desired 6.5. Both lime and manure should be worked into the topsoil thoroughly.

Best time for seeding is from August to October, or in early spring. The mixture of seed varieties to use varies greatly in different parts of the country. However, a good quality (that is, most expensive) sunny lawn seed is a safe bet.

Plate 16. Newly completed dam and emergency spillway ready for seeding. Protective fence is erected against hillside pasture. The area between the pond and the fence offers a fine opportunity for landscaping.

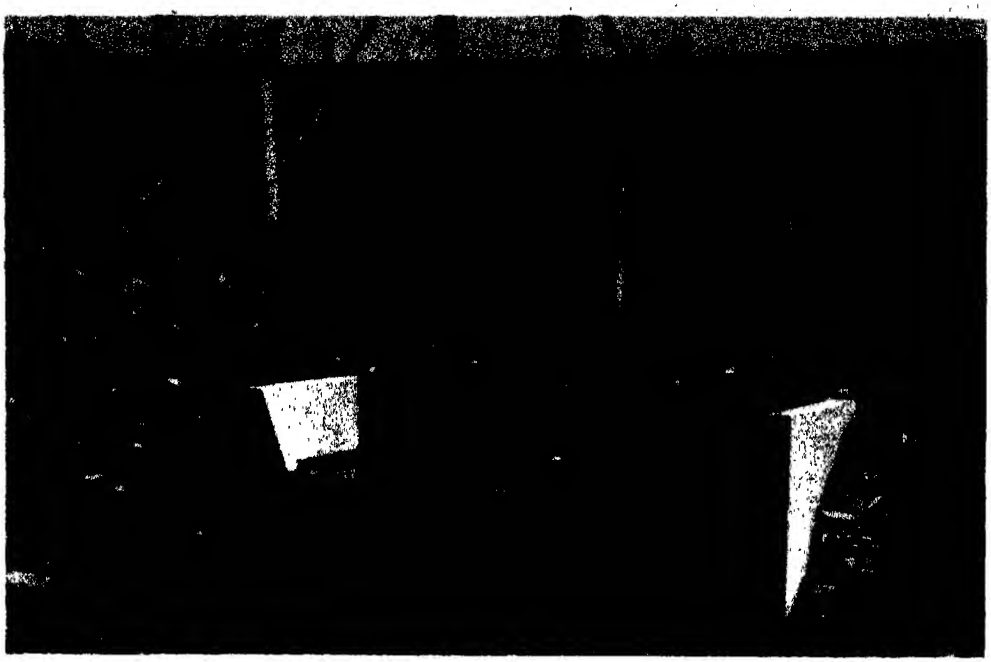

PLATE 17. Farm animals can be watered with pond water by means of a tank placed below the dam. It flows from the pond by gravity and can be prevented from overflowing by a float valve if desired.

PLATE 18. Domestic animals break down pond banks and muddy the water if they have access to it. They should be excluded from the pond by means of fences.

PLATE 19. A hedge of multiflora rose provides a natural fence as well as helping to landscape the pond. This hedge is three years old, will be livestock-proof in another year.

PLATE 20. The fish pond inevitably doubles as the "old swimmin' hole."

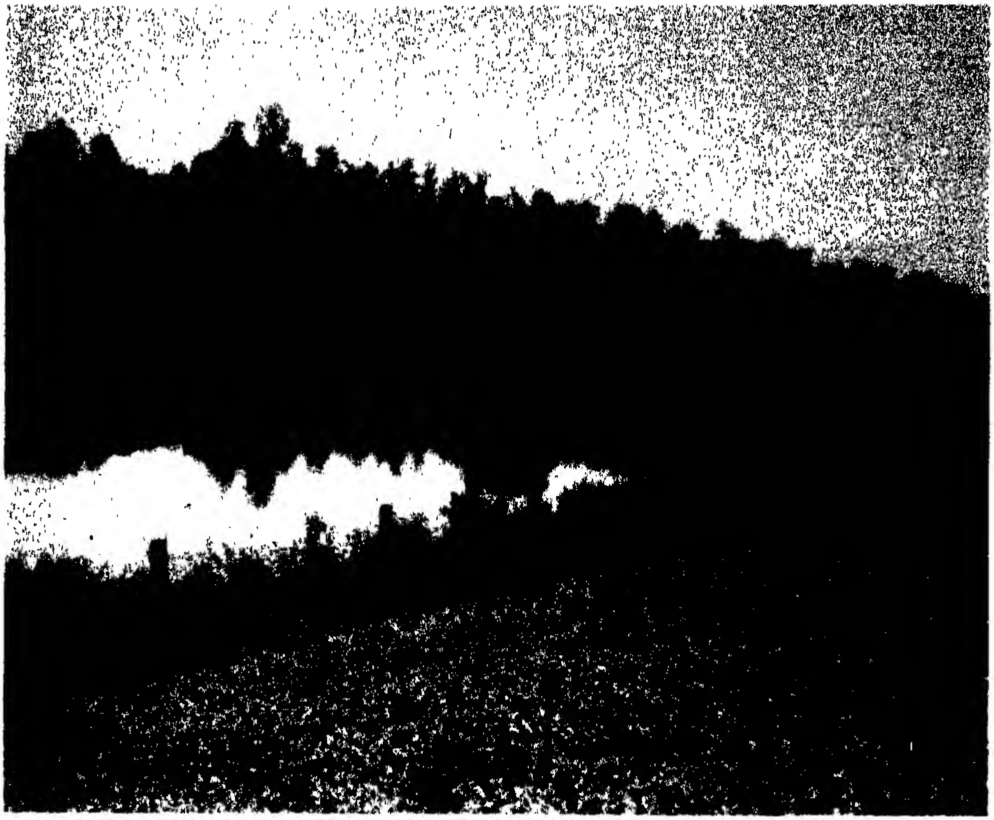

PLATE 21. Dogwoods and viburnums are planted around this pond. A ten foot wide edge of grass next to the water keeps the whole pond easily accessible. Note the fence to exclude livestock.

For the northeastern section of the United States, the mixture given below is generally dependable. For seeding mixtures in other areas, consult your County Agricultural Agent. Rate of seeding should be about 25 pounds per acre, or one pound for every 1,600 square feet (40 feet square).

Seed for One Acre of New Sod

White Dutch Clover.	2 pounds
Red Top	8 pounds
Kentucky or Canada Bluegrass	5 pounds
Domestic Ryegrass	10 pounds
Total	25 pounds

PLATE 22. Plantings of trees and shrubs around the pond add much to its beauty. It is well to keep them back from the water's edge a little way so that the shore can be used for recreation.

At the time of seeding, or just before, the area should be treated with a complete nitrogen-phosphate-potash fertilizer, formula 4–12–4 or thereabout, using about 1,000 pounds per acre (a pound for each 40 square feet). On steep areas, a mulch of straw, hay, or weeds should be applied after seeding in order to prevent washing of the soil before the plants get well started.

If construction is finished in the spring too late for a grass seeding, I suggest that a cover crop be seeded so that the ground will have some protection through the summer. The manure and lime (using burned lime in the spring) and half the fertilizer should be applied as suggested above. Oats, Sudan grass, ryegrass, or Korean Lespedeza (south of Pennsylvania) may be used as the crop with appropriate seeding rates. As the plants mature they should be mowed and left on the

surface as a mulch. In August, apply another lot of manure — about half as much as before — and either disk or spade the manure and cover crop residue into the soil. Apply another fertilizer treatment and seed as above.

Much of the pond margin may still have its original plant cover undisturbed by the construction work. This may or may not be a good sod. You will have to take stock and decide whether it needs ploughing or disking and reseeding. Sometimes it may be desirable to remove some native woody plants, do some grading work or topdress with manure, lime, and fertilizer to improve the turf. The important thing is to develop as much as possible of the area next to the pond into a fine lawn.

The lawn area will need mowing several times a season to keep it in good shape. Sometimes, where mowing is not convenient, it may be possible to keep the area trimmed by grazing a few livestock periodically. Sheep are best for this use since they will not wade in the water. Cattle may be used in cool weather and at night. Whenever animals are used to maintain the sod, it should be only long enough to do the job.

TREES AND SHRUBS ENHANCE THE POND'S BEAUTY

The pond is a nucleus around which to develop an attractive recreation spot. Plantings of trees and shrubs help immensely in the landscape plan. Some folks will desire a modest grouping in small clumps, leaving the general appearance quite open. Others will prefer a more complete planting around the water and grass area to serve as a screen and shelter. Those who wish to encourage birds and other wildlife about the pond will prefer the full treatment.

We have already discussed the use of a rose hedge-fence to protect a pond where cattle are pastured. When this suggestion is followed, the hedge should be fitted in to the landscape plan. If the livestock are to be kept out of the pond area entirely — and the lawn kept trimmed by mowing — the hedge will be only on the *outside* of all landscape plantings If the pond surroundings are to be grazed as a means of keeping the sod clipped, then some protection may be needed on the *inside* edge of the woody plantings to keep the animals from browsing them. A few multiflora rose, Thunberg barberry, or other thorny shrubs will do the job. Other browsing-resistant varieties such as bayberry and Tatarian

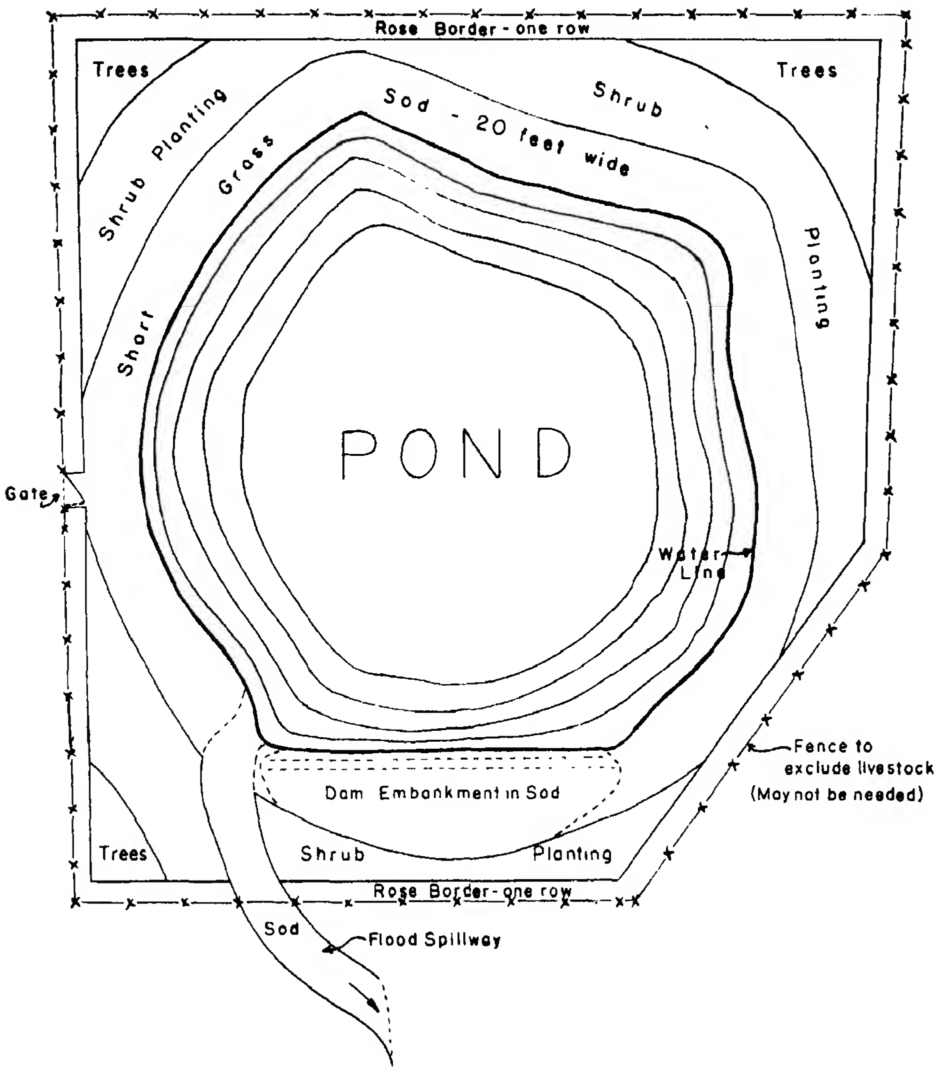

FIGURE 11. A typical pond landscaping plan.

honeysuckle, although not thorny, will also do well along the inner edge of the planting.

If one desires just a few tall plants near the pond, the planting of clumps of shrubs and trees is suggested. Their spacing may well depend upon the location of the home or roads with respect to the pond. Trees may be planted singly in order to retain their best form. Shrubs should be in groups of three or more. Similarly, perennial and annual flowering plants may be used in any way that one's fancy suggests.

A more complete planting plan where shrubs and trees surround much of the area is suggested in Figure 11. Here the lawn is bounded by a continuous shrub planting except at the dam and spillway. There may be other places too, as a spring inlet, where shrubs will not be planted. Then in a few spots, depending upon the shape and size of the whole area devoted to planting, clumps of evergreen and shade trees will be used.

The kinds of shrubs and trees suitable for these plantings are so numerous that you will have no trouble in making a selection to suit your taste. Some of those that will prove useful are listed below in Table 5, grouped according to their height.

TABLE 5. LIST OF SHRUBS AND TREES SUITABLE FOR LANDSCAPE PLANTINGS AROUND PONDS

Low Shrubs (3 to 6 feet high)	*Varieties and Notes*	*Geographic Adaptation #*
Azaleas	Horticultural varieties with showy flowers	NE, SE, RM, Pa
Barberries	Thunberg generally best	NE, SE, Pa
Bayberry	Avoid limestone soils	NE, SE
Coralberry		NE, SE, NP
Mountainlaurel	Use on acid soils only. Best in half shade	NE, SE
Roses	Multiflora, Rugosa, horticultural var., etc.	NE, SE, RM, Pa
Sand Cherry	P. besseyi good. Also Beach Plum (P. maritima) along east coast	NE, NP
Snowberry		NE, NP, SP, SW, RM, Pa
Spireas	Horticultural varieties	NE, SE

Medium-High Shrubs (6 to 12 feet high)	*Varieties and Notes*	*Geographic Adaptation #*
Arrowwood		NE
Butterfly Bush		NE, SE
Eleagnus	Autumn and Cherry Eleagnus best	NE, SE, NP, SP, RM, Pa
Fragrant Sumac		NE, SE
Highbush Cranberry	Native species better than European	NE, NP, RM, Pa
Hydrangeas	Horticultural varieties	NE, SE
Inkberry	Evergreen foliage	SE
Privet	Amur and Common are best	NE, SE
Red Osier Dogwood	Use only on damp soil	NE, NP, RM, Pa
Rhododendrons	Evergreen, mostly horticultural varieties only, on acid soils	NE, SE, Pa
Rose Acacia		NE
Shrub Lespedeza	Bicolor generally best	NE, SE
Silky Cornel		NE, SE, NP
Winterberry	Only on damp soils	NE, SE
Yews	Evergreen: *baccata and cuspidata* best	NE, SE, RM, Pa

Tall Shrubs (over 12 feet high)	*Varieties and Notes*	*Geographic Adaptation #*
Blackhaw		NE, SE
Buffaloberry		NE, NP, RM, Pa
California Privet	Evergreen	SE
Chinaberry		SE
Flowering Dogwood		NE, SE
French Mulberry		NE, SE
Hawthorns		NE, NP, RM, Pa
Holly	Evergreen	NE, SE
Mockorange		NE, SE, RM, Pa
Nannyberry		NE, SE, NP
Russian Olive		NP, SP, SW

Broad-Leaved Trees	*Varieties and Notes*	*Geographic Adaptation #*
Beech		NE, SE
Birches	Paper birch is best	NE, NP, RM
Black Locust		NE, SE, NP, SP, RM, Pa
Cherries	Various species, according to locality	NE, SE, NP, SP, SW, RM, Pa
Cottonwoods	Most useful in arid localities	NP, SP, SW
Crabapple	Floribunda one of best	NE, SE, SP, Pa
Elm		NE, SE, NP, SP
Hackberry		NE, SE, NP, SP, SW, RM

Broad-Leaved Trees	Varieties and Notes	Geographic Adaptation #
Magnolias		NE, SE
Maples	Sugar, Red, Boxelder, Silver best	NE, SE, NP, RM, Pa
Mountainash		NE, RM, Pa
Mulberries	Red, White, and Texan	NE, SE, SP, SW
Oaks	White, Red, Pin, Live, many others	NE, SE, NP, SP, SW, RM, Pa
Redbud		NE, SE, SP, RM, Pa
Serviceberries		NE, SE, NP, SW, RM, Pa
Sweetgum		NE, SE
Tuliptree		NE, SE
Walnuts	Black is most used	NE, SE, SP, SW, Pa
Willows	White, Weeping, Pussy, Golden among the best	NE, SE, NP, SP, SW, RM, Pa

Needle-Leaved Trees	Varieties and Notes	Geographic Adaptation #
Bald Cypress	In damp soils	SE
Cedars	Arborvitae, Western Red, Southern White, Port Orford among most used	NE, SE, RM, Pa
Firs	Balsam, White, Douglas among most used	NE, SW, RM, Pa
Hemlock		NE, SE, RM, Pa
Pines	White, Red, Scotch, Longleaf, Pinon, Lodgepole, Western Yellow, Loblolly among best	NE, SE, NP, SP, SW, RM, Pa
Spruces	Red, White, Norway, Engelmann among best	NE, NP, SW, RM, Pa

Key to Geographic Symbols:
NE —Northeast: Maine to Minnesota, Missouri to Maryland
SE —Southeast: Virginia to Arkansas, E. Texas to Florida
NP —Northern Plains: Dakotas and Montana to Nebraska
SP —Southern Plains: Kansas to Texas
SW—Southwest: arid country, W. Texas to S. E. California and Nevada
RM —Rocky Mountains: Idaho to New Mexico
Pa. —Pacific: Washington to California

This is only a partial list of those plants that can be used for landscaping the pond area. These are chosen for their beauty, value in encouraging interesting kinds of wildlife — birds, mammals, bees, or butterflies — and for their adaptability to plantings of this sort. Some notes are given concerning varieties and areas of usefulness in the United States. We should check carefully into each, however, before deciding to use it. Be sure that the species you want is hardy in your locality, suitable to your soils, and has no undesirable pest relation to farm crops.

Trees may be set singly, with plenty of lawn space around each, or put in clumps back of a border of shrubs as in Figure 11. In the clumps they should be spaced about 6 to 8 feet apart. The low-growing shrubs ought to be 3 feet apart and the medium to tall ones from 4 to 6 feet spaced. Rows will be similarly arranged, 3 to 6 feet apart depending on the final height of the plants being used.

Perennial or annual flowers may enhance the front of the shrub border or be arranged in small plots in the lawn. I would not want to say that one flower is better than another for these plantings. There are so many nice ones to choose from. I do think there is merit in selecting varieties that bloom primarily from mid-May to early October. This is the season when the pond is most used for fishing. This means that spring flowers may not be as suitable as others.

When the pond is to be a winter skating place some special emphasis should be placed on shrubs that hold their pretty fruits on the limbs all winter. Among these are the red fruits of the roses (especially multiflora), highbush cranberry, barberry, coralberry, winterberry, holly, fragrant sumac, and some of the hawthorns and crabapples; yellowish fruits of Chinaberry, Russianolive, and bittersweet (a vine); white fruits of bayberry and snowberry; blue fruits of the privets.

The judicious use of evergreen trees on the side where winter winds come from will help to shelter the pond and make it more comfortable for skating.

Just one more note on the pond's surroundings. Little gadgets ofttimes help make it both attractive and useful. Decorative latticework arches over gates, a fireplace for weiner roasts, rustic settees are just a few. Use your own imagination in making the pond area really "livable."

PREPARING OLD PONDS FOR FISH MANAGEMENT

IN the preceding chapters we have discussed the selection of a site for a new pond and its design, construction, and landscaping. Many farms have a pond already existing that is suitable for growing fish, or may be made so. It is almost always true that such ponds are not now in condition for good fish management.

IT MUST MEET PHYSICAL REQUIREMENTS

Such a pond should first be checked to find out how well it measures up to the physical requirements for a new pond.

It must have enough water coming in to offset evaporation and seepage. It should have very little water flowing out, not more than the volume of the pond every thirty days.

A one-acre pond with correct design and six-feet maximum depth will have about 250,000 cubic feet of water. Hence the steady outflow should not exceed six cubic feet per minute. A half-acre pond of same design and depth will have about 100,000 cubic feet of water and the continuous loss ought not be over two and one-half cubic feet per minute. Other ponds may be figured in proportion to these. It should not be subject to being flushed out by quick rainstorms.

The depth should be adequate to protect the fish against summer drouth or winter ice — at least six feet over one-fifth of the area (eight to ten feet or more in the northern tier of states) — and three feet deep all over except at narrow edges. In other words, no extensive shallows.

In size it should be at least one-fourth acre, and preferably not larger than two or three acres for a family size pond.

Conditions not in accord with these standards often may be corrected. Lack of water may be overcome by use of diversion terraces to increase the watershed, or by piping in water from a stream. Excess watershed may sometimes be reduced by diversion terraces or surplus stream water may be diked around the pond.

Lack of depth can be improved either by digging the pond basin deeper, or building the dam higher. Shallows still in the pond that has been corrected for maximum depth should be eliminated in the same way as in building a new pond. This was done by grading the dirt out of the shallows to build up the shore.

Ponds that are too small can sometimes be enlarged. Sometimes this can best be done by excavation, in other cases by raising the dam, often by a combination of the two.

Ponds in abandoned stone quarries and mine pits often pose special problems for fish management. Some quarries may have vertical sides all around with no shallow water for spawning beds. It may be possible to correct this lack by dynamiting a shelf along one side where the water will be two or three feet deep.

"Strip mining" of soft coal seams frequently leaves ponds in the abandoned workings. Ponds can often be built in these areas by deliberately sealing off the ends of the last cut. Waters filling these holes often have seepage of sulphur compounds that may make them uninhabitable to fish. A check of the hydrogen ion concentration (pH) may indicate whether the water is suitable for fish. If the pH is 5.0 or less, it is unfit for fish life. This trouble can be corrected only by locating the source of the pollutant and cutting it off.

Some gravel pits, iron ore workings, and other areas having special mineral properties may have peculiar problems too. These are so varied that no general recommendations can be given. The best way to check their condition and suitability for fish is to have a chemical analysis made of the water. Then get advice from a fish specialist.

GETTING RID OF THE EXISTING FISH

Any pond that has existed for a few years or longer will almost surely have fish in it. They may not have been stocked there by the owner but nature has her ways of taking care of such things. If the pond is connected to a stream, even if by just a small pipe, fish will find their way in. Even those entirely away from streams become stocked through birds or other animals bringing in young fish or fish eggs and depositing them by accident. And then there is the fisherman! He decides to wet a line in the pond to *see* if it has any fish. Then when he is through he feels sorry for his left over bait minnows and lets them go in the pond.

Even if you feel *sure* that the pond has no fish, check to be *certain*. And never stock more fish until you know what is already there.

How do you find out what fish are in the pond? It is very simple. Get a minnow seine about ten feet long, four feet wide and with one-fourth-inch square mesh. Fasten poles to the ends of the seine and get someone to operate it with you. Then sometime during the summer, anytime from late June to late August, run the seine along the shallow margins of the pond and see what you get. Keep the lead line on the bottom and one end close to shore. Then circle the outer end quickly into shore after a twenty- to thirty-foot fast run. It may be a revelation!

The important point is this with old ponds: They cannot be brought under management readily without knowing what is in them. If you find there are no fish there, well and good. You can stock it with what you want (provided, of course, that the water is not polluted so as to prevent fish from living in it). But if you do find fish already in it, then the questions arise: Shall I manage what is already in the pond, with no more fish stocked?; Shall I make a *corrective* stocking, and if so, what?; or shall I get rid of all fish now there and start over with a new stocking?

Usually the best solution is to get rid of the fish and start over. There are a number of reasons why this works out best. In the first place, you eliminate all the kinds of fish that are not wanted. There may be various minnows, suckers, carp, or whatnot that will contribute little to the fishing. Every pound of these fish that you have displaces a pound of some kind that you want. Thus your yield is cut down.

By stocking the species of fish you want in a pond empty of fish, you begin

with a balanced population. Growth is rapid as the water is not already overstocked with myriads of little ones. Lastly, the procedures for managing the fish you stock and the results you should get are well known whereas with a complicated mixture of wild fish, results are uncertain.

Thus we can say that in most old ponds it is a good plan to do away with the fish and restock.

If the pond can be drained, you can get rid of the fish that way, making sure that all little undrained pools are netted to get every fish. Further, by leaving the pond basin dry a week or two any eggs or young fish remaining in the mud will die. Before refilling the pond, all connections to nearby streams must be screened off with heavy mosquito mesh wire. This is to prevent wild fish from entering again.

Ponds that cannot be emptied by drawing the water out through a built-in drain, can often be drained by a syphon hose. But if this is not feasible, the fish can be disposed of by poisoning.

The simplest and best poison to use is rotenone. However, general use of this and all other poison in killing fish is a violation of the law in most states. Hence it should be done with the consent of the state fishery agency. As the objective for farm ponds is better fish management, this permission should be readily given.

Rotenone made from powdered derris root is ordinarily available for use as an insecticide in a five per cent strength. The amount needed depends on the volume of water in the pond. The cubic feet of water divided by 24,000 gives the number of pounds of five per cent rotenone needed. For an average one-acre pond, ten to twelve pounds is enough, for a half-acre pond about four to five pounds. An easy way to apply it is in a tightly woven bag, which may be fastened to a pole or to the oar of a boat and swished back and forth in the water throughout the pond until the poison is all dissolved. Using a moving rowboat is the easiest means of getting an even distribution.

The fish begin dying in a few hours and will all be dead in a day or two if the poison is up to the correct strength. Various kinds of fish respond differently, catfish being about the slowest to succumb. As the rotenone affects only the respiratory system of the fish, all killed are perfectly edible.

After removing the fish from a pond in this way, it should stand two to three

weeks before restocking. This will assure that the effects of the poison are fully dissipated.

ELIMINATE AQUATIC PLANTS

Fish do not feed on leafy plants to any appreciable degree. These plants are not needed as shelter for the fish — the water itself furnishes enough protection, especially when fertilized. Even though fish may often gather in weedy areas, as fishermen well know, it is not because they need the "weeds" for food. It is either little fish that seek escape from bigger fish, or big fish there to catch the little fish. But if the plants were not there, the same process would go on — but the big fish would not have so much trouble catching the little fellows, and not so many of the little ones would escape to grow up. As the common scourge of small ponds is over-population with small, stunted fish, it is desirable to keep down the weeds so that the big fish will keep the small ones in check. We will discuss this side of pond ecology more a little later. Now, suffice to say that we do not want any more leafy plants in the fish pond than can be avoided.

These undesired plants are of three sorts, and most old ponds have some of them. There are the *submerged* types — those that live wholly beneath the water. Such are the filamentous algae ("pond scum"), stonewort or musk-grass (*Chara*), elodea (*Anacharis*), and others. Then there are those that send stems to the surface and whose leaves lie *floating* on top of the water. The various pond lilies and some of the pondweeds (*Potamogeton*) are examples. The third type are the *emergent* plants whose leaves and stems thrust out of the water into the air. Cattails, arrow-heads and bulrushes and other sedges are among these.

If possible all of these "weeds" should be eliminated from an old pond before restocking. Different methods are needed for the three types of weeds.

The easiest way of controlling the submerged plants is through fertilization of the water. The development of a heavy plankton crop as a result of the increased fertility (which we will discuss in more detail later) colors the water. This cuts off the sunlight that is vital to these underwater plants. As a result they die, then decompose and help fertilize the water. By maintaining the fertility, hence the turbidity (color) of the water, during the growing season these plants are prevented from recurring.

As the filamentous algae (we use this term to distinguish them from the one

celled free-floating, microscopic forms that are part of the plankton) grow most during the cool days in the Spring, it is very important in their control to start fertilizing the pond early in the season, as soon as plant growth starts. This helps to prevent the algae from getting a head start on you. If you delay, control will take longer and there will be more algae to foul things up.

Pond lilies and others whose roots are in the bottom and leaves on the surface require an entirely different treatment. As the leaves are floating on top, it is not possible to smother the plants by shading out the sunlight. Instead the leaf stems have to be cut off below the water surface. They grow back again rather quickly and must then be cut again without delay. Such cutting reduces the vitality of the plant and when done repeatedly prevents recuperation. About five cuttings in a single season will suffice to kill these plants. Once eliminated they should not soon reappear.

The third type of aquatic weeds, the emergent varieties, demand the most attention. They grow only in shallow water. If the pond is built correctly (*i.e.*, without shallows) this in itself limits them to a narrow band along the shore. But it being impossible to get rid of this shallow edge (unless we build a masonry wall) there will inevitably be some sedges, rushes, or cattails coming up.

They tend to make fish management more difficult and also enable mosquitoes to escape the fish. But it should also be pointed out that they are a very valuable type of cover for waterfowl, marsh birds, and muskrats. Hence if one wishes these kinds of wildlife as well as fish, and is willing to reduce the fish production somewhat in order to have the others, the margins of the pond may be allowed to become marshy.

Control of emergent plants to make better fishing and fewer mosquitoes is either a hand-pulling or a poisoning job. Fortunately, these plants are easily rooted out of their rather loose moorings. A half an hour or so about twice a season should be enough to keep the pond edge clean. Spraying with 2-4D in tributylphosphate solvent and kerosene carrier is also an effective control.

When the pond has been rebuilt to correct physical specifications and the fish and plants cleaned out, it is ready to be restocked. This is the first step in developing the fishing. However, before we get down to the operations of managing the pond, let us in the next chapter go over a few of the biologic facts and principles that underlie fish management.

6

SOME FUNDAMENTAL BIOLOGICAL FACTS AND PRINCIPLES

FISH pond management is based on a number of fundamental biologic principles. It also takes into account some basic characteristics of the fish themselves. Acquaintance with these matters will help you to see why certain things should be done and to understand the units that make up the complex of life in a pond.

SOME CHARACTERISTICS OF FISH

To begin with, fish are "cold-blooded" vertebrates. This means that their body temperature is the same as that of the water in which they live, not approximately constant by internal regulation as in birds and mammals. In warm weather their metabolism, or body activity, is high; in cold weather it slows up. At freezing temperature, while fish continue to live, they are in a state approaching suspended animation. When their metabolism is low they take little food, hence grow very slowly or not at all. This limits the number of months in the year that the crop is growing. It also indicates the proper season for applying fertilizer. It means also that there is a difference in the growth season for fish in different latitudes.

The reproductive potential of fish is tremendous. As an example, consider the bluegill. A female bluegill sunfish almost always matures the year after hatching. She then lays a set of eggs, the number averaging about 5,000, and repeats the performance later in the summer. Thus she has produced 10,000

potential offspring before she is sixteen months old. Now for a minute let us drift off into the realm of fantasy. Suppose they all lived! That is what most fishermen want little fish to do, so let us see what would happen if they did. Of the 10,000 young bream, half would be females. The next year they too would mature and reproduce. Since each mother produces 10,000 youngsters, the total this next year would be 50,010,000 youngsters plus the 10,000 yearlings and the single pair of two-year-olds with which we started. In two years from 2 to 50,020,002.

Well, is that far enough? Or would you like to add another year to the story? If you do, be prepared to juggle figures far higher than the pennies in our national debt!

The point is that fish such as these are so prolific that the population problem is one of holding their numbers within manageable bounds. Contrast this with the birds and mammals. A mother quail lays about a dozen eggs, a woodcock only four, while a deer has only one or two fawns in a year. With them, saving the youngsters is an urgent matter. With pond fishes, "throwing back the little ones" is of no use; in fact, it is contrary to good management.

It is easy to see how a pond may become overpopulated with fish. What happens then? Well, the fish simply stop growing even if they do not always cease reproducing. Fish have greatly variable growth rates. Growth depends largely upon the food supply — and upon how much of the available food an individual fish gets. When food is easy to get, fish grow rapidly. When the food supply dwindles, or competition for it gets hard, growth slows up. Thus a five-year-old bream in one pond might weigh only one and one-half ounces, while a five-months-old one in another pond could weigh two or three times as much. This variability of growth rate of fishes is a very important factor in handling the pond. It makes it a very different matter from that presented by the rather steady growth habits of warm-blooded animals. When a fish starves (in moderation) it does not die, it simply quits growing.

CARRYING CAPACITY

We have noted that fish growth varies according to the abundance or scarcity of food. Hence the total fish growth in the pond will reflect the food available there. This is a fixed quantity at any one time We may raise it by fertilizing

the water, but there will still be a certain definite amount of food. That food can grow just so many pounds of fish and no more. This we call *carrying capacity*. It is the same principle that applies to livestock on pastures. A pasture has a carrying capacity of just so many animal units per acre.

The pounds of fish that a pond can carry may be made up in many ways. For example, if a pond has a carrying capacity of 100 pounds of fish, this weight could be composed of 100 fish weighing one pound each, 1,600 fish weighing one ounce each, or 16,000 averaging only one-tenth ounce each. The total is the same. In the first instance, all fish are of catchable size but there are no little ones to grow for next year's crop. In the third instance there is obviously no fishing to be had at all even though there are many fish. It is of the greatest importance in management to balance the fish population with the food supply. You thin out the carrots in your garden to enable the remaining ones to grow larger. At the end of the season you save enough to grow seed for next year. That idea applied to a pond is to control the population so that the greatest amount of fishing is obtained while still providing enough youngsters to make the next year's crop.

THE FOOD CHAIN

The fish grow according to how much food they can get. The food they must share is available in proportion to the fertility of the pond. Water as a medium for growth requires fertility just as does soil. The more fertile it is the more life it sustains. To understand how improved fertility increases the pounds of fish, we must look into a couple of related phenomena: *the food chain* and the *pyramid of numbers*.

The food chain begins with the minute organisms that derive their sustenance directly from the inorganic elements in the water that make it fertile (plus sunlight). The compounds of nitrogen, potassium, phosphorus, calcium, and other elements are utilized by microscopic, free-floating plants. These are green algae, blue-green algae, diatoms, and others. They are part of the great group of small free-floating creatures collectively called plankton. The plant species are called phytoplankton, or "plant plankton." They respond rapidly to fertile water and develop in such numbers that the water becomes green or greenish-brown. Among the phytoplankton are also included bacteria. These are important primarily for

their part in decomposing dead organic matter into a state useful for plant food.

The second link in the food chain is formed by small animals or zoo-plankton. These are mostly protozoans, rotifers, and crustaceans. The protozoans are smallest, being microscopic. These include such forms as *Amoeba* and *Paramoecium*. They feed on the plant plankton. In turn, many of the minute crustaceans, some as large as pin-head size, feed on the protozoans. Among these are copepods, ostracods, and cladocerans. The *Daphnia*, used in hatcheries to grow bass, is a cladoceran. Thus within the plankton microcosm alone there are three links in the food chain.

With each succeeding link, the size of the individual increases while numbers decline. Thus while the phytoplankton are numbered in almost countless billions per acre-foot of fertile water, the smaller zooplankton will be measured in millions, and the larger ones more likely in hundreds of thousands or lower millions.

While the young of both bream and bass feed on zooplankton for a time after hatching, they quickly graduate to the use of higher organisms. These are mostly the larvae and nymphs of insects, certain adult insects, various types of worms, and other invertebrates. Among the more important of these creatures are the nymphs of dragonflies and mayflies, larvae of flies and midges, caddisworms, waterstriders, and other insects, earthworms and crayfishes. It is these higher invertebrates that make another link in the food chain. Their numbers would be many thousands per acre in a fertile pond.

The fifth link brings us to the first object of pond management, the bluegill sunfish. Its food is made up mostly of the insects and their larvae nymphs, and worms as just noted, together with some small crustaceans and fish. It is representative of the group known as "forage" fishes, in contrast to the carnivorous kinds. The minnows, sunfishes, catfishes, and others belong in this class. Their numbers in a managed pond will usually be a few thousand per acre.

Next link in our rather simplified food chain are the fishes that feed largely upon others of their class. In our pond it will be the largemouth bass but in others it might be pike, pickerel, or other fish that feed on fish. The bass takes three-fourths or more of its food in fish, the balance being mostly larger varieties of crustaceans and insects. The number of carnivorous fish in an average acre will be small (except for a short time after the eggs hatch), numbering but a few hundred or even less.

We could end the food chain here, for all of the links that really belong in the pond have been discussed. However, one more is needed to tell the full story. The seventh link is the creature that eats the larger fish, especially the carnivorous ones. In the farm pond story, the last link is *you*, the fisherman; you and your family and friends who fish the pond. In wild waters the human fisherman is joined by others in this link — fish-eating birds such as herons and mergansers, and mammals like the mink and raccoon. The number of such individuals that can subsist on the readily catchable food from an acre of even very fertile water is small — possibly only a few birds, a single mammal, but only a part of the food needs of a man.

PYRAMID OF NUMBERS

Throughout our discussion of the *food chain*, the numbers of the different organisms that compose each link in an acre of fertile water have been noted. Greatest was that of the simplest creatures, while the smallest number was of the largest animal. In between, as we went from one link to the next the relative number of organisms got smaller and smaller. This relationship is known as the *pyramid of numbers*. It is closely linked to the ideas embodied in the food chain. Restated, it might be that each group of organisms, beginning with the smallest, furnishes food for another group of somewhat larger and less numerous creatures. See Figure 12.

PREDATOR AND PREY RELATIONS

Throughout this discussion we have repeatedly referred to the fact that (excluding the herbivores as rabbits, deer, etc.) one group of animals feeds upon members of another group. The plants are at the bottom of the list, as they are in all food chains, with protozoans feeding upon algae. But from there on it was animal eat animal. Each kind is a predator upon other kinds. This relationship of predator to prey, or vice versa, is fundamental in the ecology of all living things. It is one of the most prevalent of all biological phenomena. Yet it is terribly misunderstood by many people, particularly by some sportsmen and nature lovers.

The trouble comes from competition among the members of the top link of the food chain for desired animals of the next lower link. In the pond food chain

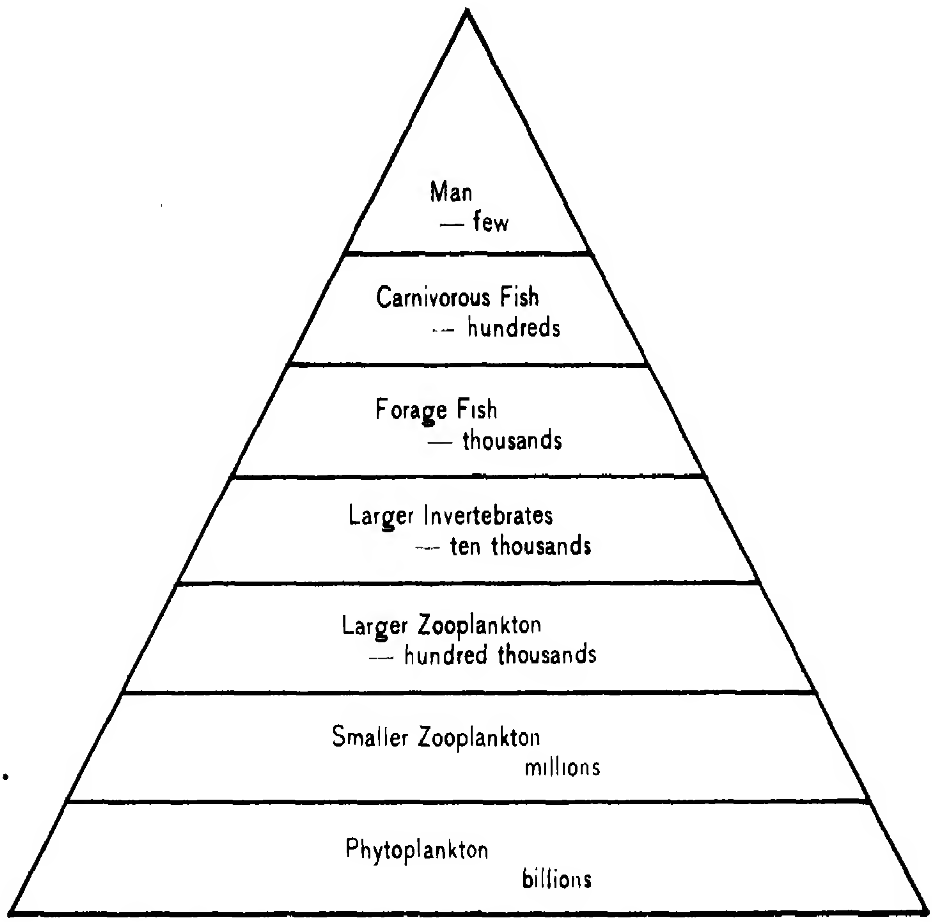

Figure 12. The Pyramid of Numbers — each group up the scale becomes smaller in numbers of individuals

discussed here, the rivalry (one-sided to be sure) is between man as a fisherman and the fish-eating birds and mammals. Thus we hear a sportsman condemn the kingfisher or the heron for eating the fish he would like to catch. Thereby, he believes, the birds spoil his own fishing.

As a matter of fact, these competing predators perform a great and necessary service. Whereas man is very selective as a fisherman, taking only certain species that he wants, the others take the easiest fish to catch. Any variety is accepted and the balance of fish in the pond is thus maintained. Further, we have noted that fish are very prolific and produce huge numbers of young. The population problem in pond management is to prevent over-abundance and consequent reduction of growth. The fish predators help to do that and so perform a service. This is as it should be since this whole natural process evolved to do just that — to keep animals and plants in balance and prevent them from destroying themselves.

So next time the old kingfisher rattles his way up to your pond for a few fish, take your hat off to him and wish him success. He will help make better fishing for you.

7

DEVELOPING GOOD FISHING

WE are now ready to begin working on the fish management part of the pond's development. The new pond, if it is a new one, is completed and filled with water. Or else, the old pond has been renovated. Our first need is to get the fish to stock the pond.

STOCKING THE POND

There are many kinds of fish that will live and grow in a farm pond. Some are good to eat, others are valueless for food. Some are fun to catch, others offer no sport at all. Of the many that *could* be used, one combination of two species has furnished consistently good results far beyond any others. These two fish are the largemouth bass and bluegill sunfish. First let us get acquainted with these two interesting fellows.

Species of Fish Recommended — Largemouth Bass, Bluegill Sunfish. The largemouth bass (*Huro salmoides* is the scientific name) is sometimes known as the largemouthed black bass, the Oswego bass, and by other colloquial names. It is one of our best game fish. The body is fairly elongated, compressed laterally just a little. It is generally dark green to black on the back, changing to lighter green and more silvery on the sides and belly. The head is large with a prominent lower jaw. An easy character that distinguishes it from its near relatives, the smallmouth bass and Kentucky bass, is the mouth. As the name implies, it has a larger

mouth than the others. A vertical line through the back corner of the mouth passes back of the eye whereas in the Kentucky bass it goes through the eye and in the smallmouth in front of it

When the bass are young there is a prominent lateral row of black spots. This series gradually fades but in many specimens can still be seen in the grown fish. These spots together with the large mouth — which makes a gap of the whole front of the fish when opened — distinguishes the young bass from certain minnows that somewhat resemble it.

The bass occasionally reaches a prodigious size, the record being over twenty-two pounds. Such fish, however, are not grown in small ponds nor in the North. The object of pond management is not to grow record sizes anyway. In actuality the majority of bass caught in small ponds will be from one to two pounds. Occasionally a larger fish may be taken, rarely over four pounds though. In fact, you should not allow the fish to remain after they reach catchable size. Big bass tend to throw a small pond out of balance and make it more difficult to manage.

The bass generally spawns in late May or early June. The fish must have reached a weight of six ounces to be able to spawn. Under the most favorable conditions some fish will reach this size in time to spawn when they are one year old. Most will wait until the second year. In the northernmost states all may need two years to mature.

The young bass at first feed on the larger zooplankton but soon add insect larvae, insects, and crustaceans to their diet. From the time they reach three inches in length, their food is mostly smaller fish The balance of their subsistence then is made up of larger insects, their larvae, and the bigger crustaceans.

Bluegill sunfish (*Lepomis macrochirus*) is called by many other names too Most commonly used are bream (often pronounced *b r i m*) and plain bluegill. It belongs to the same family of fishes (*Centrarchidae*) as the largemouth bass but differs greatly in appearance and habits. The body form is rather short and much compressed laterally. The height is much greater than its thickness. It has an elliptical (football) appearance viewed from the side. The coloring is olive green on the back, shading to lighter green and bluish on the sides. The belly is lighter, often yellow. Its colors are brightest during spawning season.

The gill cover has a prominent "ear" at the back, which is solid black and

about as long as high. There is a dark spot on the lower back part of the dorsal fin that is quite characteristic. The mouth is small.

The bluegill is most easily distinguished from other sunfishes by the black, square "ear" (having no red as the common sunfish and not being elongated), the black dorsal fin spot (which the green sunfish also has), and the small mouth (much smaller than that of the green sunfish).

Bluegills may grow rapidly to a length of six to eight inches, weighing three to six ounces. Few will go beyond that. Occasionally one will reach a half a pound, rarely will one make twelve inches and about a pound in weight. The record for southern grown fish is well over two pounds. They spawn the year after birth, even if only three or four inches long, and generally have at least two broods a year. Their nests are made by fanning a hollow in the ground in shallow water with the lower fins. These little, shallow nests are a prominent feature throughout the summer of properly managed ponds.

The bluegill is largely insectivorous as an adult, feeding on adult and immature insects as well as various worms, small crustaceans, and some aquatic plants. As fry and fingerlings they eat smaller forms of crustacea, other zooplankton, and algae.

While the bream is called a "pan fish" it furnishes considerable fun too. In many states it is officially a "game fish." Ounce for ounce it is the equal of any fish in sporting qualities. Taken on very light tackle it will give you lots of good fun. And there are few fish that make such a delightful dish when properly prepared for the table.

It may as well be said now that ponds with bass and bream must be fished with equal intensity for both kinds. It will not do to take the bass and let the bluegills go. As a matter of fact, about three-quarters of the yield will be bream and one-quarter bass.

Time to Stock. The pond should be stocked as early in the season as fingerling fish are available. The earliest possible time is July; from then on until winter is all right for placing the fish, but the earlier the better.

Fingerlings of each species should be from 1½ inches to 3 inches long About 2 inches is a good average size. There is no point in waiting until they are larger as no other fish are in the pond to bother them.

Rate of Stocking. For a one-acre pond the proper stocking rate is 100 bass and 1,000 bluegills. For other sized ponds use the same proportion, keeping the 1 to 10 ratio of the two species. The pond we used as an example in Chapter II was 0.38 acre. For it we would need 4/10 the number of fish (using the next higher even tenth) as for a full acre, or 40 bass and 400 bluegills.

The number of fingerlings needed to stock a pond to get best results is a matter for scientific determination. One should stock the full number to get best results. *It is equally important not to overstock.*

The thousand bluegills in an acre pond should grow to average 4 ounces each a year later. That makes 250 pounds. The 100 bass should average one pound each. They add another 100 pounds, or a total of 350 pounds. Then there will be offspring from the bluegills and maybe some from the bass before the year is up. That will add more pounds. It is evident then that the carrying capacity of the pond is apt to be reached or maybe even exceeded the first year.

Of course, all the fish will not survive. That cuts the figures a little. If some die, others then have a chance to grow faster. But likewise, if more are stocked than needed, each will grow somewhat slower. A pond reaches its full carrying capacity in about one year after stocking. The pounds of fish will then be the same, whether the right number were stocked or more. So you can see how foolish it is to overstock. You only hurt your own fishing.

Handling Young Fish. Great care must be taken in handling the fish enroute from hatchery to pond. The tank or can water should be cool and well aerated. If the distance is long, a tank truck will likely be used. Two hundred miles is about the limit for such deliveries. In warm weather such trips are best made at night to take advantage of the lower temperatures.

For short distances smaller containers are suitable. The standard forty-quart milk can is a good type to use and is generally available.

The fish should be handled as little as possible. When transfer from tank to cans is necessary, use a dip net. And never permit any delays. Young fish are a very perishable product.

Source of Fish for Stocking. There are four possible sources of fingerling fish for stocking ponds. The one you decide to use will depend upon circumstances. The availability of fish from each source varies by locality.

Federal hatcheries of the U. S. Fish and Wildlife Service produce these fish at many of their stations throughout the country. They are available generally to cooperators of soil conservation districts. Those who live in a soil conservation district may consult the chairman of the governing body of that district for information as to what arrangements may be made to obtain fish. If you are not informed concerning the soil conservation district, check up on it with the County Agricultural Agent or the local office of the Soil Conservation Service. If you do not live in such an organized district, the Fish and Wildlife Service, Merchandise Mart, Chicago, Illinois, may be consulted as to whether fish may be available to meet requests in your area.

Some state fisheries agencies will furnish fish to private owners for ponds. They may require an agreement providing for public fishing as a condition of this gift. If your pond is several acres or more in size this may well be a beneficial arrangement. The possibilities of getting fish from state hatcheries can be learned by writing to the conservation department of the state government, usually located at the state capital.

There are a few commercial fish hatcheries that grow and sell bass and bluegill fingerlings. To find out whether any are near enough to you to be of service, write to the U. S. Fish and Wildlife Service for addresses of these concerns.

The fourth source of fingerlings for stocking is from local ponds already under management with these kinds of fish. Particularly in soil conservation districts, this may prove to be the most ready source. Any pond that has been well managed for two years or more should provide enough young fish each year for stocking at least one other pond its own size. These should be taken in July with a small seine and promptly carried in milk cans to the new pond. Up to 400 fish may be carried in each milk can.

Other Warm Water Species of Fish for Small Ponds. The bass-bluegill combination is suitable for any pond that is capable of supporting fish life except those with very cold water. Ponds cold enough for trout should be stocked only with trout. With this exception, the bass and bluegill stocking is the best for producing good fishing. Still, some people will want other kinds either by preference, or for some particular purpose, or will take them because no others are available. Some of the other warm water fish that *can* be used are discussed below.

The crappies, particularly the black crappie or calico bass (*Pomoxis nigro-maculatus*) can be added as a third species with the bass and bream. The white crappie (*P. annularis*) also is suitable. They may best be added in place of some of the bluegills, using twenty crappies for about eighty bluegills in an acre pond. The total yield will probably be somewhat reduced as a result. Further, the yield of crappies tends to displace bass more than bream. Crappies have poor sporting qualities although they are a good food fish. The average size of crappies in the pond will be from a quarter pound to a pound when caught. They commonly have difficulty reproducing successfully in competition with the bass and bream. About the only value they add to the fishing is variety.

Other species of sunfishes in addition to the bluegill will do well in ponds. In all cases they should be used in combination with a carnivorous fish like the bass. Among the best of this group are the common sunfish or pumpkin-seed (*Lepomis gibbosus*), the green sunfish (*L. cyanellus*), the redear bream (*L. microlophus*), and the red-breasted bream (*L. auritus*).

None of these are known to be as well suited to pond management as is the bluegill. Any of them that occur naturally in your part of the country can be used and handled just as recommended for the bluegill. All reach a size of eight to ten inches and up to half a pound or more in weight.

The rock bass (*Ambloplites rupestris*) and warmouth bass (*Chaenobrythus gulosus*), which resemble sunfishes in form can be added to the largemouth bass and bream in a pond if desired. Like the crappies, they are partially piscivorous and tend to displace part of the catch of largemouth bass. Yet they are not good enough predators on small fish to keep the bluegills under control by themselves. So the largemouth or some other larger and more voracious kind is still needed. They reach a length of ten to twelve inches and a weight of half a pound to a pound. The rock bass average a little the larger of the two. They may be stocked the same as suggested for crappies.

The yellow perch (*Perca flavescens*) is one of the best pan fishes for northern waters. It grows up to about four pounds in size but most of those caught weigh a pound or less. It may do quite well in larger ponds but is not likely to succeed in small ones. The stocking rate when used with bass is 400 fingerlings per acre.

If catfishes are wanted, either the brown bullhead (*Ameiurus nebulosus*) or the yellow bullhead (*A. natalis*) are suitable. In southern states the channel

catfish (*Ictalurus lacustris*) can be used in large ponds. These are bottom feeders and compete only moderately with other fish for food. They may be stocked as a third species with bream and bass, using 75 fingerlings per acre without changing the rate for the others. Stocking with bass alone, one may use 400 bullhead fingerlings with 100 bass. The bullheads grow up to two pounds in weight, sometimes reaching nearly a pound the first year. They furnish fair sport on light tackle and are much relished as a table dish, though somewhat difficult to prepare for cooking.

Growing minnows for bait in fishing other waters is a profitable enterprise where there is a market for them. This, of course, is not pond management for fishing but just for producing a cash crop. Probably as satisfactory a species as any for this purpose is the golden shiner, or roach (*Notemigonus chrysoleucus*). It grows to a length of six to eight inches or more, hence may be marketed in a variety of sizes. Ponds used for bait production should be stocked with one species alone, using 100 per acre, preferably yearlings. Ponds as small as one-tenth acre are suitable. Fertilization should be done as in the management of other fish species. Harvesting is done with suitable types of nets.

Piscivorous species other than the largemouth bass that can be used in a pond include the smallmouth black bass (*Micropterus dolomieu*), Kentucky bass (*M. punctulatus*) and pickerel (*Esox reticulatus*). Both of these black bass are stream fishes and do not seem to thrive as well in ponds as does their relative the largemouth. They should not even be used except for northern waters where largemouth bass stock may not be available. The smallmouth and Kentucky bass (some folks think they are one species) do not reach as large size as the largemouth and do not grow as rapidly. Their sporting qualities are excellent though. Many fishermen consider them superior in that respect to the largemouth bass.

The pickerel may prove to be quite well adapted for pond use but this remains to be demonstrated. So far it has been so little used that its possibilities remain obscure. The managed ponds in which I have observed pickerel have not been very satisfactory. They do not grow as rapidly as the bass and are not as readily kept in balance with other fish. The pickerel's sporting qualities are mediocre, and its flesh though good is bony. The body form, as with all the pike family, is long and thin. Its weight rarely exceeds a pound in small ponds

Before leaving this discussion of the kinds of warm-water fishes that may be

stocked in a farm pond, I wish to reemphasize the point made at the beginning. The largemouth bass and bluegill sunfish are the best combination to use. They have proved successful and dependable in ponds over much of the country. No other fish have produced as good results. Other species are less useful either for sport or meat, are difficult to keep in balance with other fish, give poorer yields; or are unproven as yet. So unless you have some very good reason for changing, use the largemouth and bluegill. That still leaves one type of pond stocking unsettled — the cold-water pond.

Trout for Ponds. The distinction between warm-water and cold-water ponds is not entirely one of water temperature although that is very important. The point involves the conditions in a pond that will permit the use of various kinds of trout instead of the fishes thus far considered. To a considerable degree, ponds that are suitable for trout are not good for bass and sunfish. As a matter of principle also, bass and sunfish should not be stocked in ponds that have direct water connection with existing trout waters. As good trout waters are not over-plentiful, it would be unwise to contaminate them with additional species of fishes.

The first criterion for a trout pond is low temperature. The surface temperatures in the hot summer months should not exceed 70° Fahrenheit. Both the rainbow trout (*Salmo irideus*) and the brown trout (*Salmo fario*) can live in waters that rise to about 70° for only short periods. The best pond trout, the brook or speckled trout (*Salvelinus fontinalis*) needs still colder water, in which the maximum summer temperature ought not go above 65° F.

Trout require more oxygen in the water than do other fishes. Their lower limit of tolerance is about five parts per million of dissolved oxygen. To assure that a pond will not have an occasional oxygen deficiency, the water must be well aerated. This means water movement — inflow and outflow. Ponds that are questionable in this respect should be tested for dissolved oxygen at the time when flow is least, water temperature highest, and decay of vegetation greatest. This is the critical time. The test is easily made by a chemist, a civic water department technician, or a fisheries biologist.

These requirements of temperature and aeration are not commonly found in ponds. Trout ponds will, therefore, be few. They will usually be dammed trout

streams, or ponds fed from trout waters. Occasionally an unusually fine source of spring water, by itself, will supply a trout pond.

Trout ponds that are cold enough to support brook trout should be stocked with this species. They can tolerate summer temperatures up to 65° F. It is better suited to pond living than the others and may even reproduce itself there if spring-run gravel beds are present. The rainbow trout is suggested for ponds too warm for brook trout but where summer temperatures do not exceed 70° F. for many hours at a time. Despite its normal migratory habit, the rainbow proves a better pond fish than the brown trout. Neither species will reproduce in a pond and thus must be maintained by periodic restocking.

Trout ponds connected directly with trout-inhabited streams may never require stocking. The stream, if productive, will provide a continuing source of young ones. For ponds that need stocking, fingerlings at the rate of 300 per acre are recommended. Growth of the fish depends upon the adaptability of the pond to fertilization. If the change of water is too rapid to permit use of fertilizer, the rate of growth and yield will be similar to that in wild waters. When fertilizer can be used to improve food supplies, the fish may reach legal size and half a pound in weight in a year. Their ultimate size will depend upon how many fish are permitted to stay in the pond, how long they are left before catching, and how much supplemental feeding may be done. Large trout *can* be kept in a rather small pond — you have seen them at fish hatcheries — but the food supply remaining constant, the bigger you allow them to get, the fewer there will be.

POND FERTILIZATION

Fertility of water as of soil is a measure of ability to produce and sustain life. Subsoil will not grow vegetables, nor will pure sterile water grow fish. All water that has not been artificially purified will contain some dissolved or suspended substances. What these are, how much there is, the form they are in, and the affinities among them will set the level of living things the water will support.

Reduced to basic elements, the chemical plant foods needed to grow vegetables in the garden are the same that are needed to grow aquatic plants in the pond. These water plants, in turn, are needed to sustain animal life. This is the

PLATE 23. Applying fertilizer to the pond. In small ponds it can be distributed from the shore. The water movement spreads it evenly. In big ponds a boat is needed.

food chain principle that we discussed in Chapter VI. Those elements that man can most easily apply to raise the fertility of the water are the same as those used in the garden: nitrogen, phosphorus, potassium, and calcium. The common commercial fertilizers contain these in the form of nitrates ($NaNO_3$) (or ammonia compounds), phosphates (P_2O_5), muriate of potash (K_2O), and lime ($CaCO_3$).

These chemicals dissolve in the water and add to the natural supply of these and other plant foods. As a result, tremendous quantities of minute plankton organisms develop. First are the one-celled algae, then the protozoans, and finally the larger zooplankton such as the little crustaceans. This food supply is consumed by insects, worms, and others which are in turn used as food by the fish that we want to grow

PLATE 24 This well-fertilized pond in Mason County, West Virginia, was stocked on October 30 with fingerling largemouth bass and bluegills Both grew enough to produce young the following June, and twelve inch bass were caught in July

Kinds of Fertilizers to Use Experience has shown that the best and most dependable results with fish have been with the inorganic, commercial types of fertilizers Organic fertilizers of many types *can* be used but there will be less certainty of results

The formula that seems to give the best plankton growth is 8-8-4 The first figure shows the pounds of nitrogen in 100 pounds of the mixture, next is the pounds of phosphate (P_2O_5), last the pounds of potash (K_2O) The remainder of the hundred pounds, 80 pounds in this instance, is made up of other elements that hold the nitrogen, phosphorus, and potassium There will usually still be some

quantity left of the hundred, which is made up of some "filler." In most fertilizers today, limestone is used for the filler, thus providing needed calcium.

To understand further how these fertilizers are made up, let us show you one way in which the 8-8-4 can be made. Nitrate of soda contains 16% nitrogen. So to get 8 pounds we will need 8 × 6¼ or 50 pounds of $NaNO_3$. Using 20% superphosphate, we will need 40 pounds to get 8 pounds of phosphate. As muriate of potash is about 50% potash, we need 8 pounds of it to get 4 pounds of potash. That makes a total of 98 pounds. So we need 2 pounds of filler to complete the 100 pounds. For this we will use finely ground limestone. Then the formula looks like this in tabular form:

$NaNO_3$	—Nitrate of Soda (16% N)	— 50 pounds	— 8 pounds nitrogen
P_2O_5	—Superphosphate (20% P_2O_5)	— 40 pounds	— 8 pounds phosphoric acid
K_2O	—Muriate of Potash (50% K_2O)	— 8 pounds	— 4 pounds potash
$CaCO_3$	—Limestone	— 2 pounds	—filler
		100 pounds	

The fertilizer for the pond can be made up this way by mixing together the four ingredients if you so desire. Some farmers mix their own fertilizers for other crops and you may be one of them.

Generally it will prove more convenient to buy a complete fertilizer all mixed. Since 8-8-4 is not a standard formula for farm crops, it will be necessary to use another and then adjust it. The simplest way to do this is to use a formula with the phosphorus and potash in the right ratio, then add nitrogen. The following four commonly used fertilizers suit the purpose. One or more should be available in your area. They are 4-8-4, 6-8-4, 5-10-5, and 3-12-6. Table 7 shows how to adjust these mixtures to an 8-8-4 ratio.

TABLE 7. ADJUSTING COMMON COMMERCIAL FERTILIZERS FOR FISH POND USE

Commercial Formula	*Pounds of Nitrate of Soda* to Add to 100 Pounds of Formula*	*Total Pounds of Resulting Mixture (in ratio with 8-8-4)*	*Number Pounds to Use per Application on One-Acre Pond*
4-8-4	20	120	120
6-8-4	10	110	110
5-10-5	25	125	100
3-12-6	45	145	97

* In hard water ponds, use sulphate of ammonia in place of nitrate of soda and try to get the mixed fertilizer with ammonium nitrogen too.

Poultry and sheep farmers may have surpluses of manure and prefer to use this type of fertilizer on their ponds rather than buy the commercial type. Farms having cattle and horses usually need all the manure on crop fields but any manures can be used on ponds if you wish. Since some of these manures do not have an adequate proportion of phosphate for pond use, this element should be added before applying to the water. Table 8 lists the manures and the amount of phosphate needed with each together with the unit application for a one-acre pond. They are given in the order of preference for pond use.

TABLE 8. MANURE FERTILIZERS FOR FISH POND USE

Type of Manure (Fresh)	*Amount per Application for a One-Acre Pond*	*Pounds of 20% Superphosphate to Add per Application*
Poultry, Sheep	400 pounds	20 pounds
Cattle, Horses	600 pounds	

Manures without straw in them are best for use on ponds. This aids in keeping the pond clean. The use of manures may make the pond less desirable for swimming. Cattle manure may possibly spread disease to other cattle if the pond water is used for watering them. These points should be considered before deciding to use manure in the pond.

Other organic fertilizers are not recommended for general use. Meals, hay, tankage, and many other types may be all right but so little is known about their use in ponds that trying them would be an experiment.

Applying the Fertilizer — Time, Quantity, Frequency. When a new or renovated pond is stocked with fish, the first application of fertilizer should be made. If you know a little ahead of time when the fish will be stocked, it is even better to spread the fertilizer a few days ahead. This gives an opportunity for the plankton to develop and be ready for the young fish. In other years following stocking, the first lot of fertilizer should be put on the pond as soon as plant growth starts in the spring. When the lawn or pastures begin to get greener is the time to spread fertilizer in the pond.

The amounts of various fertilizers needed for a single application on a one-acre pond are given in Tables 7 and 8. Unit quantities for other ponds will be

PLATE 25. Fertility of the water checked by the color test. This pond is just right — the white object disappears at a depth of twelve inches.

proportional In the pond we used as an example earlier which was 38 acre, we would take 4/10 (using next higher tenth) of the acre pond quantity. Suppose we are to use 5-10-5 plus extra nitrate. We need 4/10 of 100 or 40 pounds per application.

The fertilizer may be distributed from the shore in small ponds. It dissolves quickly and water action then spreads it evenly through the pond. In ponds more than 150 feet across, the use of a rowboat is advisable. It is well to spread the fertilizer in water from one to six feet deep, avoiding the shallow edge and the deeper parts.

After one lot has been applied, the pond should be looked at again in a week. The test as to when another treatment is needed is the color of the water. The

PLATE 26 A simple way to check the fertility of pond water. If your cupped hand disappears before your elbow goes under, the color tests all right. If you can still see your hand after your elbow is immersed, apply more fertilizer.

growth of plankton gradually adds color to the water, greens, browns, and reds according to the kinds most abundant, and the density of this color is therefore a measure of the quantity of food. This assumes, of course, that the color of the water is not due to the presence of silt stains, or some other pollutant. To measure the density of water coloration, immerse a light object into the water as deep down as it can be barely seen. This depth is the scale used to decide the adequacy of fertilization.

This is called the "turbidity" test, even though turbidity usually refers to the presence of silt in water. When a light object disappears from view at twelve inches or less, the turbidity is adequate for fish management. About the simplest way to make this check is with your arm. Cup the hand so that the

fingers are at right angles with your forearm. Dip the arm straight down into the water until your fingers can no longer be seen. If your elbow is at the surface or above, fertility is all right. If your elbow is beneath the water, more turbidity is needed — hence more fertilizer.

Make weekly applications of fertilizer until the twelve-inch turbidity condition is attained. Thereafter, treatment should be made whenever the water color lightens so that the depth visibility is more than twelve inches.

There are numerous pond-water sources that have a natural *tea* color before any fertilizer treatment. This is usually due to the presence of tannic acid arising from decomposition of wood, leaves, etc. Such water is found commonly in the northeastern states and is commonly called "bog water," owing to its origin in cedar swamps and similar places. It prevails also in southern cypress swamps. This type of water responds well to fertilization but because it already has a stain color in it, the turbidity test should be based on eight to ten inches of visibility instead of twelve.

Continue to use fertilizer throughout the warm months whenever the color test shows the need. The last treatment should be made at or before the first killing frost in the fall.

The amount of fertilizer required in a full season to keep the pond in this condition will vary with each pond. Ponds on naturally fertile soils require less treatment than those on poor soils. Some ponds receive fertilizer automatically from surface or under-drainage from crop fields or barnyards. (Rarely a pond can get too much manure fertilizer from a barnyard resulting in suffocation of fish. Proper diversion of excess manure water can correct this if it should occur.) In most cases, five or more applications will be needed in a season; that is, 500 or more pounds of fertilizer per acre. Often more is required the first year of a new pond than later, if in a poor site. Sometimes the reverse will be true when the pond is built on a fertile site. Rarely will more than 1,000 pounds be needed on an acre pond in one year. If it is, then the pond is probably losing its fertile water from too much outflow.

CONTROLLING AQUATIC PLANTS

The importance of keeping leafy plants out of the fish pond has already been noted. These plants include three distinct types: the submerged plants such as

the filamentous algae, elodea, chara, and others; rooted plants with floating leaves, like the water lilies, and pondweeds; and the emergent sedges, rushes, cattails, and numerous aquatic grasses. Whatever their type, the effects on the fish in the pond are practically the same. They furnish shelter that protects the young fish from their predators, including the older bass. This commonly results in too high a survival of young bream with consequent over-population and stunting at a size too big for bass to eat and too small to furnish fishing. At the same time the bass do not get enough food to grow rapidly.

These water plants have other effects on the pond too. Some are definitely undesirable while others may be good. The weedy areas produce mosquitoes in such numbers that many will escape the fish to become a nuisance. In malarial areas they are also a menace to health. On the other side of the ledger are the interesting wildlife that some of these plants feed and shelter — waterfowl, shore birds, marsh birds, muskrats, frogs, and many others. Those who want a great variety of wildlife in and around the pond will have to compromise the best conditions for fish.

Fertilize to Subdue Submerged Plants. Each of the three types of water plants requires a different means for prevention and control. The submerged plants are most easily kept out as they are discouraged by the regular practices followed in growing fish. They require sunlight just as do all green plants. The sunlight must penetrate into the water to reach them. Thus it is easy to see that fertilizing discourages the under-water plants by developing plankton in such numbers as to color the water and cut off the sunlight. Ponds with adequate depth and dark enough water color will rarely have too many algae or other submerged plants.

These plants grow very rapidly in early spring. Thus it is important to begin fertilizing as soon as there is any sign of underwater plant growth. If you let them get ahead, it will take longer to remove them later. Once they have gotten well started it takes a little longer for the water to color up and kill them. When they are killed they float to the surface, become pond "scum," and then decay. During this period of decay, the weeds break down by bacterial action into plant foods thus contributing to the fertility of the pond. Care should be taken not to add any more commercial fertilizer than needed to maintain the twelve-inch color test. Sometimes the rapid decay of weeds in addition to heavy plankton growth results in a temporary oxygen deficiency harmful to the

PLATE 27. Surface-floating plants, such as the water lilies, can completely clog a pond and ruin the fishing. They must be eliminated by repeated hand pulling.

fish. If there is any evidence of this — fish dying or gasping at the surface — rake out the weeds quickly and stir up the water and add some fresh water if possible.

Complaints about excesses of underwater plants are quite common. Usually they reflect a lack of pond depth, too much fresh water flowing in and out of the pond, or inadequate fertilization. The cure, of course, is to get rid of the cause.

Floating-leaved Plants. The white water lilies, lotus, yellow cow lily, and other plants that send their limp stems to the surface where the leaves lie floating cannot be controlled by the treatment used for submerged plants. As the leaves are exposed to the air, the coloration of the water does not greatly affect their access to sunlight although it does discourage their establishment.

Most of these plants are tough and are hard to check. There is only one practicable way and that is to cut off the stems below the water surface. They will come right back again. As soon as a new crop of leaves appears, cut them again. About five cuttings in a single reason will take the life out of the roots enough to kill them.

Once eliminated they do not come in again very easily. It is a simple matter to cut and kill a fresh new plant that occasionally appears. But do not let them get ahead of you. They can choke the whole pond in time.

This is a good place to mention plant poisons. It may be that some of the new types of plant poisons will prove useful and safe in killing pond plants. So far too little is known of their effect on fish and other organisms to recommend their general use. Their effectiveness in killing various kinds of aquatic plants is not well known yet either. If you are tempted to try any of them — such as

Plate 28. Filamentous algae, or "pond scum," thrives in clear water, can be controlled by proper water fertilization. This kind of algae impedes good fish management.

2-4-D ("Weedone"), ammonium sulfamate ("Ammate"), or "Benoclor" — make your trials in a small spot at first, and use light treatments. Other poisons that have long been used to control algae — copper sulfate and sodium arsenite in particular — are not needed when you have proper control through fertilization. The sodium arsenite is especially dangerous and should never be used except on prescription by an expert.

Suppressing the Emergent Plants. Those plants whose roots are in the soil beneath the water and whose stems and leaves rise into the air provide the most constant problem. Mostly they are grasses, sedges, rushes, and cattails. They occur in shallow water almost exclusively. Hence their control is partly in correct pond construction. Remember what was said before: no water under three feet deep except at the margins.

PLATE 29. Shallow water encourages growth of sedges, cattails and other emergent aquatic plants. They are detrimental in a fish pond.

PLATE 30 Clean pond margins help fish to grow faster and keep down mosquitoes Pulling water weeds by hand from the shallow edges is an easy chore if done regularly.

As the pond edges will always be shallow for a few feet out, this is the place where our attention to these plants is needed Just as with the water lilies, the fertilizer treatments do not deter them, if anything it helps them The only effective control is hand pulling or poisoning This sounds at first like a big task but it really is not bad at all

Being rooted in saturated soil, they are loosely anchored A few minutes two or three times a summer will usually take care of them It is best to pull them when in a swim suit, or at least wading Grab each plant firmly at the base, pulling slowly at first until the roots give Then pull it fully and dispose of it on shore. It is amazing how many can be pulled in a quarter of an hour Spraying with 5% 2-4D (2 pounds) in solvent of tributylphosphate (2 quarts) and with kerosene (five gallons) as a carrier is effective for many of these plants

8

THE FISH HARVEST AND POND MAINTENANCE

WHEN TO START FISHING

THE proof of the pond is in the fishing. And the beginning of the fishing season is not long delayed even when mere fingerlings are stocked. The superb food supplies induced by the fertile water promote very rapid growth. If stocked in good season — say by early October — the bream should reach three to four inches by winter and the bass five to seven inches. With the coming of the warm days of spring and after the end of the winter spell of dormancy, growth picks up again. It is very important to fertilize the water early enough in the spring to have plenty of food available. The fish need all the insects and other food organisms they can get then in order to grow rapidly

The breeding season is in early May to early June, depending upon latitude For the bass there is only one spawning season. If they have grown to a weight of six ounces by mid-Spring they will likely spawn. If they have not reached this size — and they will not unless they have had plenty of food all the time during the warm seasons — they cannot spawn for another year.

The bluegills will almost always spawn the first year after stocking. If they do not succeed early in the season, they will later in the summer. And by mid-Summer the stocked bluegills should be from five to eight inches long and weigh from two to six ounces each.

The rules for deciding when to begin fishing a newly-stocked pond are

simple. Rule 1: defer fishing of each species until some of them have spawned successfully. Then the future supply is assured and the breeders can safely be taken. Rule 2: take any and every fish that is worth keeping. When the bream are five inches or more and the bass nine inches or more, they provide good fishing and good eating.

In some states the fish conservation laws may set the limit higher than nine inches, and may limit the season of fishing. You are supposed to adhere to these rules even though they are biologically unsound for managed ponds. Some states have had the wisdom to enact laws exempting managed ponds from the season, size limit, and creel number restrictions.

Once fishing for either species has begun it should be continued at every opportunity for the rest of the year through the next spring breeding season. During the winter months the fish are inactive and there is no use bothering with them. But at other seasons there is no limit to the fishing. That does not mean, of course, that you will find *good* fishing all the time. But it is true that *you can't overfish a good well-managed pond*. As soon as you have taken a considerable number of fish the competition for food will lessen and they will no longer bite. This may last a few days or a week or two. Soon the fish growth catches up to food supply and they will again strike your bait. Catch as many as you can, and then the process repeats itself. Just so long as the species you take has spawned successfully and has produced a reasonable number of young, there is no danger to the pond. The real danger lies in *failing* to fish the pond enough. Remember if you do not take the crop it is wasted. It never gets any larger than the carrying capacity of the water. Worse, it degenerates from competition when unharvested, just like an abandoned garden.

MAINTAINING THE FISHING

Bream fishing will begin in all ponds the season following stocking. This will be from nine to eleven months from the time the young fingerlings are received. Bass fishing may begin at the same time, provided the bass have reproduced. Many times the bass will not have bred and then they should be protected for another year. Those caught by accident should be carefully handled in the shallow water and released. In the second year fishing with both kinds should

be in full swing by July. However, it is always advisable to examine the fish balance in the pond during the early summer. This may be likened to an annual inventory that will reflect any shortages that may exist. Upon it we will base any corrections that are needed.

The purpose of the summer check-up is to make sure that both species have reproduced successfully. The presence of adequate numbers of young fish of both not only proves successful spawning but reflects proper balance.

The technique of the summer check-up is both simple and enjoyable. It employs the minnow seine in the same manner described in Chapter V for discovering what kinds of fish are in an old pond. The seine is run along the shallow margins of the pond in a number of spots taking samples. Indentations of the shoreline are especially good places to "corner" the little fish and catch them easily. Examine each seineful of fish. There should be numbers of young bluegills and at least some young bass. After a number of samples have been looked over, judge the conditions by the following rules:

A. Both species present — pond is in good balance. Fish it hard.

B. Bream abundant, bass absent — bass have not been successful in reproducing, bream have become dominant. Fish bream very hard. Seine surplus young bream out and dispose of them. Add more bass fingerlings, if available, up to 150 per surface acre.

C. Neither species present — both failed to reproduce due to excessive competition. Fish bream very hard. Seine excess stunted bream and dispose of them.

D. Bass present in good numbers, bream absent — bream have not been successful in reproducing, bass have become dominant. This happens very rarely and the cause may be hard to ascertain. Fish the bass very hard. Restock bream only in case further seining and fishing show that the original stocking failed for some reason. If adult bream are present, do not restock, but be sure fertilization is adequate.

In seining the pond in this manner for the young fish, you will rarely catch the bigger ones. Once in awhile you may corner a large bluegill and catch it in a minnow seine but not likely a bass. However, your seine may turn up some other kind of fish. This proves that nature has added something to the pond, or else you got a mixture in the fish stocked. In any case, the presence of extra kinds of

fish is a sign for careful watching. There need be no alarm as long as the fish balance remains all right and the fishing is good.

The pond should be checked each summer to see about the fish balance — sometime from late June to mid-August. Provided your pond fertilizer treatments have been up to standard, and the harvest has been adequate, each year's check should show the pond in balance. Theoretically, this should go on forever. In practice for one reason or another, the pond may get badly out of balance after a time. If not complicated by other kinds of fish, the balance may be restored by the methods noted. But if it gets too badly out of balance, or develops too many unwanted fish, it may be necessary to clean out the fish and start over. This may be done by draining the pond, retaining the right numbers of young bass and bluegills for restocking, and disposing of the remainder. If impractical to drain, the entire fish population can be poisoned as described in Chapter V. Then you will have to get another supply of young bass and bluegills for restocking.

In cases where a pond cleaning is needed to get rid of an unbalanced fish colony, the only loss is one year's fishing. The next year after restocking, the new fish will be ready to harvest again.

ANNUAL YIELD

How much fishing will a pond actually provide? What returns in pounds per acre can one expect? The answers to these questions are about as uniform as would be answers to similar questions about home vegetable gardens. For example, an average yield of potatoes might be 250 bushels per acre but there would be some gardens yielding only half that and then again some others will produce 400 bushels per acre. So it is with fish yields.

The carrying capacity of ponds is a more uniform figure than yield. Carrying capacity of well-managed ponds will range from 300 to 600 pounds per acre but are most commonly about 400 pounds per acre. Yields are customarily about half these figures, 150 to 300 pounds per acre and generally about 200.

With an individual pond, the carrying capacity should remain constant year to year. But the yield may be quite variable according to the proportions of different sizes of fish present. One year the pond may be overcrowded and the yield drop; then with proper adjustments the number of larger-sized fish will increase the next year and the yield rise again.

There is considerable variation in yields in different parts of the country. The general trend is for somewhat larger yields in the south, with its longer growing season than in the north. Taking 200 pounds of fish per acre is a fair probability in the southern half of the United States. In the northern half, yields of 200 pounds will not be very common and in the northernmost tier of states it may average below 150 pounds.

These yields refer only to the largemouth bass and bluegill sunfish combination. The proportion of each species in the total yield should be about three-fourth bluegills and one-fourth bass, by weight. Thus a one-acre pond yielding 200 pounds of hook and line caught fish might give you fifty bass averaging one pound each and 600 bluegills averaging four ounces each.

The harvest that can be expected from other species and combinations is pretty much an unknown matter. So far as we know, it is likely to be less than the yields noted above. Exceptions to this are minnow ponds and carp ponds that can produce much greater quantities of fish — but no fishing.

Some fertilized trout ponds may produce more than 100 pounds of trout in a season. How often this can be done is not known.

METHODS OF FISHING

Probably as good a way as any to start an argument among fishermen is to advocate a particular bait or lure or technique of fishing. Everyone has his own opinions and is welcome to them. That is one of the things that makes fishing so fascinating.

There is little doubt but that the surest bait to catch bluegills is the old dependable earthworm. Other live baits such as grasshoppers, crickets, grubs, and other insects from one-half inch to one and one-half inches long may be used with generally good success. But there is little romance in luring the bluegill to the hook with these natural foods. For those who like to pit their ingenuity against the wiles of the fish, the artificial lure is the thing. Then too, you need not take time to dig worms in the manure heap or garden.

For bluegills the lures should imitate its natural foods, at least in a general way. Flies made of bits of feathers, tinsel, wood, and thread concocted in endless varieties of design and color may be made at home. Those who take their

fly tying quite seriously acquire a special vise and other tools of the art as well as a great variety of bird feathers and other materials. Others may choose to purchase flies of standard designs at the sporting goods stores. Either dry or wet flies may be used although the latter are generally more successful with bream. The best size is a medium trout fly (on hooks size 10 or 8).

Any kind of tackle will serve to catch bluegills. As a minimum, a piece of string and a hook are all you have to have. If the line is strong (and it doesn't need to be very strong), the fish can be yanked out of the water with the first pull. Of course that is not much fun. To really give some zest to the play, use the lightest tackle you can get. A seven and one-half foot fly rod weighing three ounces, or an eight to eight and one-half foot rod weighing four ounces is ideal. Combine with this a silk or nylon, fly-fishing line testing about ten pounds. Now you will really have some sun. Ounce for ounce, the bluegill is as sporty as any of them.

Combine this light tackle with artificial fly lures and match your wits with Mr. Bluegill. He may win out on you before you get a large enough catch for dinner. Then you may concede the sporting contest and go after him for the meat — with live bait.

Fishing for the black bass is quite a different matter. He is not so easily tempted with any old bait or lure tossed out to him. But he too can be taken on either live bait or artificial lures, with heavy line or light tackle.

Among the better natural baits for taking the largemouth are "minnows," crayfish, hellgrammites, small frogs, large white grubs, and "night crawler" earthworms. A word of caution is in order concerning the use of "minnows" in the farm pond. Whatever kind you use — real minnows, small goldfish, stone cats, or whatnot — never let them escape alive. There is always the chance that one of these species might survive and reproduce to the detriment of the pond. So always hook them very securely before throwing your line in the water.

It is with the artificial lures that you can *really* have fun in bass fishing. The variety of lures possible is much greater than for the smaller bluegill and, believe me, the tackle manufacturers have not missed their chance. The marvelous array of brilliantly colored and ingeniously designed plugs, spoons, spinners, trollers, wobblers, wigglers, streamer flies, and countless others is wonderful to see. And fun to use too!

What kinds *you* use will eventually become a part of your own little idiosyncrasies. But there are a few generalizations that can be made. Some of the lures are conceded to be widely successful and should be in most tackle boxes. One old reliable is the "redhead," a wooden, floating plug with white body and red head, usually with a fluted front end. It operates near the surface with an undulating or wiggling movement, depending upon the individual design. Another favorite is the wooden minnow, either solid or jointed, green, black, and silver with vertical stripes and glass eyes.

Spinners of connected swivels with one or two gold or silver blades and a hook at the end are used mostly in trolling but can be cast. Some have a treble hook, others a single hook disguised in feathers. The latter are especially good with fly rods.

A heavy metal wiggler with a spinner in front and single hook for pork rind bait is quite popular. These last two baits sink when not in action, hence sometimes get caught in weeds (if your pond is so unfortunate as to have them). Some of these heavier than water lures are fitted with hook guards to make them "weedless."

A "spoon" is a single piece of bright metal, oval and concave. It usually has a single hook or one treble hook, sometimes rigidly fastened but generally eyed on. Among the better varieties of spoons are those painted with two or three colors in diagonal bands.

Streamer flies are becoming increasingly popular for bass fishing. They are so named for the long feathers in the fly that extend far beyond the hook. Best hook sizes for bass flies are from eight to two.

There are countless other types, some which make little pretense of resembling a living food organism, others that imitate one or another of the bass' natural food. Only your own "expert" opinion can decide which one you prefer.

As to bass tackle there are three types. The plain fish pole and line is adequate for fishing live bait or for trolling. But it does not permit the additional sport of handling the artificial lures with a casting or fly rod.

The bait casting rod is four and one-half to five and one-half feet long and rather heavy as rods go. It is used with the heavy (one-half to five-eighths) ounce lures that are thrown from the end of the rod with a whipping motion, all the

while unreeling the line. Once in the water it is reeled in with varying speeds and movements aimed at making the bait lure the bass to strike it. A braided silk casting line of fifteen- to eighteen-pound test is about right. The skills involved in handling the cast and maneuvering the lure in the water add much to the sport.

Fly fishing for bass is without a doubt the most sporting style. A rod eight and one-half or nine feet long and weighing from five to six ounces is used. The line should be of about a fifteen-pound test. Using streamer flies or spinners, the battle to land a fighting bass provides the finest thrill in farm pond fishing.

CLEANING AND PREPARING THE FISH

Most of the pleasure of a pond is in the fishing itself, although the gourmet may disagree. So let us say that the eating of our fish catch is a fitting finale to the day's sport. To make certain that the repast will be in keeping with the viand, one must prepare the fish with skill.

Cleaning the fish is not a tedious chore when the knack is mastered. First rule is to do the job promptly. Dead fish do not stay fresh long, especially in hot weather. While fishing, the catch should be kept on a stringer in the water to keep them alive as long as possible. Using a small holding pool is a good way too. When you leave the pond for the day, take your fish knife and cleaning board and go to work.

Since most of the catch will be bluegills, and they will be rather small, it is well to know how to dress them with speed. First, remove the scales. Holding the fish firmly by the tail, run the knife forward with the dull blade riding under the scales and on top of the skin. Do this all around the fish until all scales up to the head are off. Keep a pan of water handy for dipping and rinsing. Next, eviscerate with a sharp blade. Cut from the vent forward to the gills, then around each side just back of the head. Cut off the head taking with it the gills and entrails. The last step is to remove the two pairs of lower, forward fins — the pectoral and pelvic fins. These are clipped out easily between the thumb and knife. Note that the tail, dorsal, and ventral fins remain.

Dressing the bass requires a somewhat different procedure. Begin by eviscerating, doing this just as with the bluegill including the removal of the head. Now the fish should be skinned rather than scaled. The skin of the bass is

rather bitter and detracts from its flavor if left on. Cut through the skin around the dorsal fin and along the top of the back from the fore-end to the tail. Use a sharp, thin, pointed knife. Now cut under the skin at the lower fore corner on one side. Grasping this loosened corner of skin with one hand, hold the flesh under it with the other and draw the skin slowly off toward the tail. Use the knife to cut under the skin if it starts to tear off flesh. Then turn the fish over and repeat on the other side.

Next the fish may be filleted or, if you prefer, cooked as it is. To fillet, use the back fin as a handle, and with the other hand, cut sharply through the flesh along the backbone from end to end. Then cut the side slab of flesh off by running the knife blade along the ribs. Repeat on the other side. This leaves the back fin, tail, back bone and ribs in one set. If any small bones remain in the meat, pull them out by hand.

When the fish are cleaned, wash, wrap in wax paper and keep in refrigerator until used.

RECIPES FOR COOKING BASS AND BLUEGILLS

The ways of cooking fish are many, and the little variations in recipe for each style are as numerous as cooks. All agree that to get the best in flavor and texture, the fish should be cooked slowly and only long enough to loosen bones from flesh and make the meat tender. Any longer cooking loses some of the delicate flavor.

The four recipes given below are standards for the novice. Those wishing greater variety may consult any of the cookbooks. And no doubt, as you become an expert yourself, you will develop some little wrinkles that will mark you as a talented chef.

Fried Fish

The prepared bluegills and filleted bass are sprinkled well with salt and pepper and set aside for ten to fifteen minutes. Dip each piece in a cup of egg and milk slightly beaten. Then roll in a mixture of white flour and cornmeal, half and half (or either one alone). Now sauté in hot fat, preferably butter or bacon grease. Be careful to avoid too much heat. Smoking fat detracts from the flavor.

Allow four to six minutes and then turn each piece over and cook the other side just about as long. The finished job should be moist inside with a crisp, brown crust. Remove to an absorbent paper for draining before serving. Serve with a sauce, such as tartar, or plain.

The fish may be fried in deep fat instead of sautéd if you prefer. Proceed as with French fried potatoes, cooking from four to six minutes. Cook only one layer of fish at a time.

You will recall that in preparing the bluegills, the tail and dorsal fin were left on. The tail will cook to a crisp and may be eaten. The back and ventral fins can serve as "handles" if you wish, but are too bony to eat.

Broiled Fish

Take the prepared bluegills and the bass fillets and sprinkle well with salt, pepper, paprika and lemon juice, both inside and out. Cut a piece of parchment paper somewhat larger than each piece of fish. Butter the paper thoroughly and fold in its edges to hold the cooking juices. Place each fish in a paper on the broiling rack. Cook for about fifteen to twenty minutes in a moderate oven. Serve with lemon pieces and parsley.

Fish Cakes

Start with cooked fish — boiled, broiled or fried, fresh or left-overs. Flake the fish, making sure that all hard bones are removed. Add an equal quantity of mashed potatoes, and one slightly beaten egg for each pound of fish. Add enough milk to give a good consistency for moulding and season with salt, pepper, onion, and other suitable condiments. Shape into cakes of suitable size and about an inch thick.

Fry in shallow fat until well browned and crusty, then turn and repeat on the other side. A tomato or Creole style sauce goes nicely with fish cakes.

Fish Chowder

Fry slowly two ounces of cubed salt pork. When partly cooked add one small, chopped onion and continue frying until the pork is crisp. Now transfer to a saucepan, add one cup of water, one cup of small diced potatoes and boil slowly under cover for fifteen minuess. Add one pound of flaked, cooked

(boiled, broiled or fried) fish with all bones removed and simmer for another five minutes.

Just before you are ready to serve, add three cups of scalded milk and bring to the boiling point. Pour into warm bowls or tureen, sprinkle with salt, pepper,. paprika and add a tablespoon of butter. Serve with crisp crackers or toast.

On Eating Bluegills

It is fitting that we should finish our story by eating our fish. Just a final note on eating bluegills is in order. First, its flesh is of fine flavor. But it is also quite bony. So it is well to handle it in a manner that will get rid of the bones most easily.

First, hold the fish with tail in one hand and back fin in the other. Pull out the back fin by pulling it upwards. This will take the backbone with it. Remove lower fin the same way Now, divide fish in two lateral halves by spreading open the top. Take each half and double back the flesh against the *outside*. This will expose the ends of the row of remaining bones which can be easily pulled. Now it is all flesh Try it this way. It's easy, and the pleasure of eating is assured